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SPATIAL AND TEMPORAL DISTRIBUTION OF THE FORENSICALLY SIGNIFICANT BLOW FLIES OF LOS ANGELES COUNTY, CALIFORNIA, UNITED STATES (DIPTERA: CALLIPHORIDAE)

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By

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SPATIAL AND TEMPORAL DISTRIBUTION OF THE FORENSICALLY SIGNIFICANT BLOW FLIES OF LOS ANGELES COUNTY, CALIFORNIA, UNITED STATES (DIPTERA: CALLIPHORIDAE)

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University of Nebraska, 2019

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Forensic entomology although not a commonly used discipline in the forensic sciences, does have its niche and when used by investigators is respected in crinimolegal investigations (Greenberg and Kunich, 2005). With many species of forensically significant insects being regionally specific, it is often difficult for forensic entomologists to as confidently translate regionally specific studies across drastically differing geographic regions (Brundage, et al., 2011).

The purpose of this study is to help create a better temporal and geographic distributional understanding of the blow fly species present in Los Angeles County, California, United States. Twenty-five locations from four ecoregions (coastal mountains, urban, interior mountains, and desert) were regularly surveyed using baited traps for forensically significant blow flies throughout Los Angeles County from July, 2017 through January, 2018.

In total 10,875 arthropod specimens were collected, of which 4,933 were the target family Calliphoridae. Six genera and twelve forensically significant species were recorded from the county during this time period. In addition to the current survey, all specimens from the Los Angeles Museum of Natural History and from select literature were included revealing an additional three species not collected during this current survey. *Chrysomya rufifacies* and *Lucilia sericata* comprised most the specimens recorded [collectively 87.9% (61.3% and 26.6% respectively)].

Several species define two ecoregions, *Lucilia cuprina* was only recorded below 1,000 feet elevation in urban disturbed environments, and *Calliphora livida* and *Calliphora vomitoria* define the San Gabriel Mountains having only been found there above about 4,000 feet elevation. Temporally, with Los Angeles having a rather Mediterranean climate year-round it is not surprising that most species have wide temporal distributions with only *Calliphora terraenovae* significantly restricted to only May-June.

In summary, summer was the most species rich season with all 15 species recorded, and the San Gabriel Mountains had the highest diversity with 13 of the 15 species occurring there.

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CHAPTER 1: INTRODUCTION AND LITERATURE REVIEW

BLOW FLIES COMMUNITY MAPPING

Forensic Usefulness

With forensic entomology's broad definition of "use of insects and other arthropods in medico investigations" many subdisciplines have been utilized to aid in that work, including: entomotoxicology, applied ecology (interaction among organisms, geographic distribution, temporal distribution, habitat preference, etc.), and developmental biology (Amendt, et al., 2010; Gennard, 2012).

The utility of forensic entomology has been shown through various of forensic investigations but all of these specific tools require a great deal of previous research and background to be useful in an investigation and be allowed to stand in the court of law (Greenberg and Kunich, 2005). Most forensic entomology casework revolves around relatively recently deceased individuals (hours to weeks exposed) as this is the most likely time a body will be found due to the extensive search for missing individuals or the prominent smells of decomposition (Gaudry, et al. 2004). This type of casework involves developmental biology, where the specimens collected from the body are identified, and aged to the best of the ability of the participating entomologist, and this is used to help determine a minimum post mortem interval (Hall and Huntington, 2008). However, when a body is overlooked or hidden for a period longer than this initial period of insect activity, it is the evidence the insects leave behind that is used. Following this period where fresh or live specimens can be collected, empty puparia remaining in the soil are typically most useful. Although species identification can be more difficult for puparia, it is possible due to morphology of the puparia itself (Amorim and Ribeiro, 2001), from

examination of the oral sclerites left behind in the puparia cap from the third instar maggot, and in recent years DNA markers have been successfully been used to identify puparia to species (Yusseff-Vanegas and Agnarsson, 2017; Bharti and Singh, 2017). With the species found on a body and the local community composition of blow fly species known, a better understanding of the possible season of activity during a postmortem interval can better be determined (Weidner, et al., 2015).

The contemporary work of Whitworth (2006) has greatly clarified the systematics of the many North American species of blow flies which were originally reviewed in the preliminary works of Hall (1948), and in regionally specific portions by James (1953, 1955) and Hall and Townsend (1977).

As an active forensic entomologist on the West Coast of the United State, the regional works providing clarity to our blow fly biodiversity and distribution are unfortunately limited only to the preliminary work of James (1955) and more recently in Northern California by Brundage et al., 2011. The excellent work in Santa Clara County, California by Brundage et al., 2011 significantly influenced my process and was the inspiration behind my decision to replicate a similar study in Southern California, a region currently devoid of specific blow fly community surveys.

Reasons for Thesis Location

Los Angeles County, California was chosen for many reasons. First, as Head Entomologist and Assistant Curator to a new live tropical butterfly exhibit opening up in Buena Park, California I needed to live near Orange and Los Angeles Counties. As far as

forensically significant species of blow flies in my region, when reviewing James (1955) between the two counties, Los Angeles County was significantly more diverse with 13 species recorded in Los Angeles County and 4 species recorded from Orange County. Desiring to become more familiar with the West Coast species, and wishing to explore more diverse ecoregions, Los Angeles County was more likely to be my ultimate location.

I then spoke with one of my mentors, David Faulkner, a well-known forensic entomologist on the West Coast, and asked about where most of his forensic casework was focused in regard to these two counties. He explained that Orange County, as a smaller county frequently had better resources than Los Angeles County and so he was more frequently called in to work with Orange County investigators. With Los Angeles County being a rather large county, both in land area and in population, Los Angeles rarely requests forensic entomology assistance in cases. Therefore, with a large collection of forensically significant insects recorded by David Faulkner from Orange County over the years, I decided to conduct my survey across the larger, and less recorded Los Angeles County.

As someone who has been training under a West Coast forensic entomologist for several years, but who was doing coursework in the Midwest, I wanted to follow a thesis path that would involve becoming very familiar with our local California blow flies. In the Midwest my traps were generally overrun by two or three common species (*Cochliomyia macellaria*, *Phormia regina*, and *Lucilia sericata*), but with Los Angeles County being home to several different ecoregion and with a historic record of more diverse blow fly species, I wanted to gain a familiarity with the diversity that would be

hard to refute. For these reasons I decided a temporal and distributional survey would be an excellent way to become familiar with the local species and create an additional tool for future Los Angeles County forensic entomology casework.

BLOW FLIES (DIPTERA: CALLIPHORIDAE)

Taxonomy

The first extensive taxonomic review of the blow flies of North America was that of Hall (1948) and specifically for California was that of James (1955). In modern times the revisionary work of Whitworth (2006) has greatly clarified the taxonomy within the family and his reorganization is the currently accepted standard.

Specifically for my region of study, Los Angeles County, there are three subfamilies, six genera, and fifteen species of forensically significant blow flies (based on James, 1955, and the species additionally recorded during this survey, summarized below in Table 1).

Table 1. Forensically significant blow fly species of Los Angeles County, California.

Subfamily	**Genus**	**Species**	**Author**
Calliphorinae	*Calliphora*	*grahami*	Aldrich, 1930
		coloradensis	Hough, 1899
		livida	Hall, 1948
		vomitoria	(Linnaeus, 1758)
		latifrons	Hough, 1899
		vicina	Robineau-Desvoidy, 1830
		terraenovae	Macquart, 1851
Chrysomyinae	*Chrysomya*	*megacephala*	(Fabricius, 1794)
		rufifacies	Macquart, 1843
	Cochliomyia	*macellaria*	(Fabricius, 1775)
	Compsomyiops	*callipes*	(Bigot, 1877)
	Phormia	*regina*	(Meigen, 1826)
Luciliinae	*Lucilia*	*cuprina*	Wiedemann, 1826
		mexicana	Macquart, 1843
		sericata	(Meigen, 1826)

GOALS

To map the geographic and temporal distribution of forensically significant species of Calliphoridae for Los Angeles County, California. Additionally, my goal was to become intimately familiar with the forensically significant species within Southern California for my professional work as a forensic entomology teacher and expert witness.

To conclude, my goal was also to create a baseline of knowledge for Southern California forensically significant blow flies so that future climate change and habitat destruction/environment alterations will have a preliminary work to observe future changes in population composition or species distributions.

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CHAPTER 2: TEMPORAL AND DISTRIBUTIONAL BLOW FLY SURVEY

ACTIVE SURVEY MATERIALS AND METHODS

Survey Area

This survey was conducted in the densely populous Southern California, Los Angeles County (34º 3’ N 118 º 15” W; 2017 estimate of 10 million+ residents, United States Census Bureau). At 4,058 square miles the average population density is over 2,100 inhabitants per square mile (United States Census Bureau), with areas varying drastically in density with the ecoregions of urban densely settled, the high desert and coastal mountains moderately populated, and the interior mountains sparsely populated. The climate of Los Angeles County is classified as Mediterranean under the Köppen climate classification (Kottek, et al., 2006) with an average temperature in the warmest month above 72 F/22 C and average yearly low of more than 32 F /0 C in their coolest months, and less than 40 mm of precipitation.

Regions of Los Angeles County were identified from each other by elevation, land use, and ecosystem type and parallel the EPA classification of Los Angeles County ecoregions. From this review of the county, four approximate regions were identified (Fig. 1) and are used for reference

.

Figure 1. Four ecoregions identified within Los Angeles County, California, based on usage type, elevation, and geographic placement.
The four regions are classified as such:

1. Urban. Characterized by extensive urbanization from the coastline up to the foothills of the San Gabriel and Santa Monica Mountain ranges, with little more than county parks breaking up the anthropogenic landscape. 0-2,000 feet elevation. Notable cities: Burbank, Glendale, Los Angeles, Pasadena, Alhambra, Santa Monica, Inglewood, Compton, Redondo Beach, Long Beach, San Pedro, Downey, Whittier, Pomona, and Claremont. (Fig. 1 green outline/ Fig. 2)
2. Coastal Mountains (Santa Monica Mountains). Characterized by dry summers with frequent fog on the Pacific Ocean side, and wet winters with average rainfall of 18-22 inches. 200-2,800 feet elevation. Notable cities: Westlake Village, Agoura Hills, Calabasas, and Topanga. (Fig. 1 dark blue outline/ Fig. 3)
3. Interior mountains (San Gabriel Mountains). Characterized by rolling peaks and numerous valleys with dry summers and cold rainy winters with snow above 4,000 feet elevation frequent in the winter. 1,200- 10,000 feet elevation. Notable cities: Castaic, Santa Clarita, Agua Dulce, and Acton. (Fig. 1 red outline/ Fig. 4)

4. Desert (Mojave Desert). Characterized by little rainfall annually and extreme temperature ranges with summer temperatures of 100+F and winter lows of 25F common. 2,300 -4,300 feet elevation. Notable cities: Neenach, Lancaster, Palmdale, Lake Los Angeles, and Pearblossom. (Fig. 1 lite blue outline/ Fig. 5)

2.

3.

4.


5.

Figures 2-5. Figure 2: Urban. Figure 3: Coastal Mountains (Santa Monica Mountains). Figure 4: Interior Mountains (San Gabriel mountains). Figure 5: High Desert (Mojave Desert).

The desire was to choose trap locations throughout the county with relative even spacing and with replicates within each region.

To begin, I reached out to all family and friends in the county regarding my need for suitable trap locations and was able to secure several locations. Following this coincidentally was the annual Los Angeles "Bug Fair" held in the Los Angeles Natural History Museum, an event where I have been exhibiting an educational booth every year for the last six years. With as many as 18,000 visitors recorded from past shows (personal communication with museum staff from previous years) attending the two-day event on May 20th and 21st, 2017, the possibility to obtain the rest of my trap locations was exactly what I needed. For that year I also unveiled a new educational table devoted solely to the field of forensic entomology, a theme that had never been presented at the Bug Fair before which drew in a great deal of interested guests who I gave fliers to requesting I use their private property to hang my traps (see Appendix 1 for the flier).

Table 2. Trap coordinates and habitat type for thesis collection sites.

Site ID	Site Name	Habitat Type	Latitude (N)	Longitude (W)	Elevation (ft.)
A	Marina Del Rey	Urban	33°58’49”	118°25’58”	19
B	Westchester	Urban	33°57’57”	118°24’42”	136
C	Compton	Urban	33°51’11”	118°13’15”	81
D	Whittier #1	Urban	33°56’15”	117°59’55”	226
X	Whittier #2	Urban	33°56’38”	118°00’10”	230
U	La Habra	Urban	33°57’01”	117°59’08”	397
V	Glendale	Urban	34°09’09”	118°12’15”	931
W	Monrovia	Urban	34°08’38”	117°59’50”	548
E	Carson	Urban	33°49’34”	118°13’22”	28
Q	Long Beach	Urban	33°52’05”	118°10’41”	56
Y	West Hills	Urban	34°11’20”	118°36’56”	821
G	Malibou Lake	Santa Monica Mts.	34°06’34”	118°44’45	906
O	Malibou Creek	Santa Monica Mts.	34°06”28”	118°42’49”	605
F	Topanga	Santa Monica Mts.	34°04’21”	118°36’15”	1,554
R	Tuna Canyon	Santa Monica Mts.	34°03’40”	118°36’38”	1,441
K	Stunt Road	Santa Monica Mts.	34°05’27”	118°39’32”	1,605
S	Lancaster #1	Mojave Desert	34°44’52”	118°10’38”	2,318
P	Lancaster #2	Mojave Desert	34°45’00”	118°17’47”	2,437
T	Neenach	Mojave Desert	34°47’00”	118°38’34”	3,025
I	San Gabriel Mts. #1	San Gabriel Mts.	34°16’07”	118°09’50”	3,665
J	San Gabriel Mts. #2	San Gabriel Mts.	34°18’40”	118°00’35”	5,229
M	San Gabriel Mts. #3	San Gabriel Mts.	34°28’39”	118°04’51”	3,936
N	San Gabriel Mts. #4	San Gabriel Mts.	34°35’08”	118°40’43”	2,769
L	San Gabriel Mts. #5	San Gabriel Mts.	34°33’08”	118°39’25	2,392
Z	San Gabriel Mts. #6	San Gabriel Mts.	34°21’08	117°56’26”	6,936

Bait Trap Design

My desire was to create a bait trap where the flies would be collected and safe away from the generally noxious bait used for such traps. A study I originally was influenced by was Brundage et al., (2011) trap design had specimens drowning in a water bait mixture which proved successful in keeping pests such as ants and wasps at bay, however of the 40,404 calliphorids collected, only 34,389 (~85%) could successfully be identified due to damage from this trapping method. My first decision in trap design was

to search for a solution to this specimen damage issue by keeping the bait and the captured insects separate from contact.

The resulting trap I designed was made originally from combining BioQuip “Mini Mosquito Breeder” (product #1425DG) to create a three chambered trap. This trap was specifically designed to keep collected insects clean and away from the noxious bait which can damage fragile specimens. The three-chamber design allows specimens to enter through the middle, become trapped in the upper chamber, all while the bait is kept separate in the bottom unit away from collected specimens. With the traps secured in place by cord from the middle unit, the tops (where the specimens are collected) and the bottoms (where the bait is stored) can be removed, all while leaving the center secured in place for future use or immediate resetting.

I approached BioQuip co-owner Ken Fall about possibly producing this trap in a large quantity for me to purchase for use during my thesis, and our resulting work together cleaned up my rough and ready modifications into a streamlined new BioQuip product now available for sale.

Made from durable, drop-proof polypropylene plastic, these traps can be used in adverse weather conditions or used continually for several years outdoors without degradation. Their ability to be completely disassembled also allows for thorough cleaning of the traps, a highly desirable feature especially when dealing with baits such as putrefied liver. Also included with the trap is a vinyl insert for the bottom chamber which can be used to hide the bait from view if desired.

Traps when assembled stand 11 ¾” inches tall (298mm) and have a maximum width of 3 ¾” inches (96mm) (Figure 7). Their compact design makes them ideal for use in urban environments for surveys and makes them ideal for storage and transportation. With 1/2-inch entry holes for attracted specimens, a wide variety of insects have been successfully recorded within traps ranging in size from Pomace Flies (2-4mm) and Drain Flies (2-8mm long) up to *Nicrophorus* sp. (~30mm long) and medium sized Noctuidae moths with wingspans as large as 40mm.

Figure 7. RC Bait trap, BioQuip product #1420RC. Fully assembled minus the hanging cord.

Adjustments after week #1

After the first week two items were changed due to a disappointing turnout in specimen numbers.

First, it was desirable to keep bait frozen until used to maintain a more uniform time spent putrefing from week to week. The original plan was to make batches of bait in quantities large enough to supply bait cups for three separate weeks, with bait thrown away after each week of use. To maintain a uniform exposure to the bait, after it was aged as a batch in a bucket it was then divided up into the bait cups and all 80 bait cups were frozen. Then as each week came by, the cups were to be removed from the freezer the morning of and kept in a cooler until being set throughout the day to then thaw and start to attract flies.

This decision was one that had not been tested before the beginning of the survey and in hindsight was a rash decision. I should not have tried out a new technique that had not been tried in previous runs of the trap and it proved to be detrimental. With the first week of trapping it was obvious that the traps were not performing to the same success that they had been during the previous eight months. I decided to revert back to using bait that had never been frozen, a method which had proven successful in all previous runs of the trap.

This was not the only issue with week #1's traps. Despite being tested in Indiana, South Carolina, Arizona, Illinois, Nebraska, Colorado, Utah, and two other areas in California, a new issue arose. The Argentine Ant (*Linepithema humile* (Mayr, 1868)) was a major pest in dozens of the traps throughout the county, with the biggest issue being their ability to walk in, pull apart my collected blow flies, then carry the pieces out and back to the nest. During the first week I was even texted by the residents of location X excitedly telling me that their trap had caught 8 "big flies" but upon picking it up after the

allotted 48-hour period, I found only 2 intact flies but many pieces of wings and partial legs along with many ants actively removing smaller bycatch from the trap.

To remedy my ant problem, a one-inch by one-inch strip of Vaportape Mini-Strip was placed in the top compartment of the trap in the collection area to kill any insects that entered the top. This immediately proved to be successful during my second week of trapping as the numbers of undamaged collected blow flies increased drastically (65 for week #1 to 306 for week #2; Table 3) and many traps now had a large number of dead ants that came wandering in looking for a meal but died shortly after entering.

Table 3. Weekly dates of collection, the season they fall under, and the total number of Calliphoridae collected for that week as well as the bycatch collected.

Week #	Dates	Season	Calliphoridae Collected (Bycatch Collected)
1	July 17th-21st, 2017	Summer	65 (359)
2	July 31st-Aug. 3rd, 2017	Summer	306 (871)
3	Aug. 14th-17th, 2017	Summer	140 (346)
4	Aug. 28th-31st, 2017	Summer	232 (830)
5	Sept. 12th-15th, 2017	Fall	409 (356)
6	Oct. 2nd-5th, 2017	Fall	588 (621)
7	Oct. 23rd-26th, 2017	Fall	1,639 (1,485)
8	Nov. 14th-17th, 2017	Fall	1,129 (625)
9	Dec. 4th-7th, 2017	Winter	373 (383)
10	Jan. 23rd-26th, 2018	Winter	52 (66)

Bait preparation

Liver was used as the basis for the bait, a commonly used attractant by past surveys (Brundage et al., 2011; Hwang and Turner, 2005; Weidner et al., 2015). A combination of beef and chicken liver were used as the attractant inside my traps. This decision was made as beef liver was more readily available in my area in large quantities

at lower cost than chicken, but I wanted to have a mixed of livers to give a wider range of volatiles in my bait. In the months leading up to the start of this survey a combination of different beef and chicken liver ratios were sampled in Jasper County, Indiana searching for an ideal ratio. Beef to chicken rations of 1:1, 1.5:1, and 2:1 were run over several weeks with bait sitting active for two to three days near Lake Bannett on the Saint Joseph College campus during the Spring of 2017. No detectable difference was noted from the three bait types either in average quantity of flies collected or the ratio of species sampled. With beef liver available in larger quantities in my home town I decided to follow a ratio of 2:1 beef to chicken liver.

The liver was purchased in Greenfield, California throughout the entirety of the survey and was cut into 1.5 to 2-inch squares with the butcher thickness of approximately half an inch throughout. All cut liver was then weighed to match the desired ratio of 2:1 beef to chicken liver (Table 4) and placed into a large Home Depot bucket with sealable lid and stored in my garage for approximately four weeks to putrefy. During those four weeks the contents were stirred two or three times to make as homogeneous a bait as possible. After the bait had "matured" it was then distributed into 80 sterile urine sample cups with a maximum capacity of 4.5 fluid ounces. The cups were filled with approximately 3 ounces of bait, resealed, bagged up, and stored in several additional Home Depot buckets while they awaited use. For the ten weeks of this survey, a total of three bait preparations were needed.

Table 4. Beef to chicken liver weights and ratio's used throughout survey.

Preparation #	Beef Liver	Chicken Liver	Ratio
1	176.0 oz.	88.0 oz	2 : 1
2	160.0 oz	77.6 oz	2.1 : 1
3	144.0 oz	71.0 oz.	2 : 1

To save money I also adjusted during week four to start using bait for two weeks of collection with bait from one week resealed and used again the following week. The bait cups showed little signs of deterioration after their short 48-hour period of activity so the reuse of bait was an easy way to save money.

Table 5. Bait preparation records per week as well as notes on when bait was reused.

Week	Prep. #	Notes
1	#1	Set straight from freezer, not thawed or allowed to sit beforehand. No vapona strip.
2	#1	Bait never frozen
3	#1	Bait never frozen
4	#1	Reused from week #3
5	#2	Bait never frozen
6	#2	Reused from week #5
7	#2	Bait never frozen
8	#2	Reused from week #7
9	#2	Bait never frozen
10	#3	Bait never frozen

Trap placement

With Los Angeles County being a rather large county, and the drive to pass by all 25 of my traps being about a 450-mile round trip run, the route was split into two halves, a northeastern half, and a southwestern half. The northeastern half encompassed all traps in the communities north of me, through the San Gabriel Mountains, and the Mojave Desert (locations D, X, U, W, V, I, J, Z, M, S, P, T, N, L). The southwestern route handled all urban locations to the west and the Santa Monica Mountains (locations Q, C, E, B, A, Y, G, O, K, F, R; Figure 6).

Figure 6. All thesis trap locations within Los Angeles County, California for this active trapping survey.

During the trap placement, the trap was opened and a Vapona pest strip was placed in the top section. The bait cup was quickly shaken, 1 fluid ounce of tap water was added (to help fight desiccation of the bait), the bait was shaken again, the lid removed and placed in the bottom of the trap followed by the bait cup and the trap was put back together. The trap was hung, and the unique trap number was recorded along with the time and temperature at the location.

Trap duration active

The traps were active for 48 hours, a time that was decided upon for several reasons. The first was because of the trap size limitations. With the traps being rather small, only 4 ounces of bait could be used at each time. This small amount of bait was susceptible to drying out in the dry Southern California climate during the summer

months. Also, as requested by several thesis location volunteers, the trapping period needed to fit into the work week, so their front yards would be putrefied liver free during the weekends when they were out in their front yards doing yard work or having friends over. With the route being broken into halves, the traps needed to be set in back to back days (either Monday and Tuesday, or Tuesday and Wednesday) and then retrieved in back to back days (Wednesday and Thursday, or Thursday and Friday).

Trap retrieval

Traps were retrieved from their locations and the bottom section with bait was removed. The bait was resealed and placed back into the cooler with the trash bag lining to be latter discarded or saved for one additional run.

Occasionally specimens would die from the Vaportape Mini-Strip (BioQuip product 1196F) in the middle section of the trap, and these specimens were included in the batch from the top section. The top section of the trap containing the Vapona pest strip and most specimens was removed, and a closed clean bottom section was secured, locking in any specimens still alive as well as keeping the Vapona fumes from dissipating further. Time and temperature at trap retrieval were recorded.

Specimen processing

All specimens collected were sorted and pinned or preserved in 95% ethyl alcohol within 48 hours of trap retrieval. Traps each day after retrieval were brought in and one by one were opened, the insect toxicant (Vapona) strip was removed and sealed in a Tupperware container to be reused the following week, then all sampled insects were

emptied onto a clean white paper towel sheet for sorting. Calliphoridae were removed from bycatch and sorted by eye into likely genera and pinned. After pinning, blow fly specimens were counted and logged into a Google Doc excel spreadsheet.

Bycatch was sorted from the blow flies and counted into small ½ or 1-dram screw cap vials filled with 95% ethyl alcohol and were placed alongside blow flies for storage. Large bycatch (Vespidae, Noctuidae, Tachinidae, etc.) were pinned alongside the blow flies and included in the bycatch count. In many traps throughout the county consistently there was a presence of the Argentine ant (*Linepithema humile* (Mayr, 1868)) which I assume was attracted to the pungent bait and after entering the trap was enticed to stay by the freshly killed insects. All Argentine ants were removed from bycatch, were not included in the bycatch count, and were the only arthropod to be discarded. On several occasions upwards of 2-300 of these ants could be found dead inside the traps. Most bycatch was simply counted and placed in the alcohol vials for storage, but occasionally single specimens were kept out and pinned or point mounted for later identification due to their interesting presence or appealing morphology for my personal collection.

Blow flies were pinned near the base of the forewing to avoid as much of the thorax as possible and pinned at a 30-35 degree angle to aid in speed of identification under the microscope as their body would then be visible at a more pronounced angle to allow viewing of lateral and dorsal features simultaneously.

All sampled arthropods were organized in BioQuip specimen shippers (1025BX Unit

Tray Shipper) or large Cornell unit trays (1025A). Taped to the top of each unit tray was a data form on which was written the trap location (as the letter identifier), the date of collection, and the collection ID number. If necessary, at the bottom a note of (1 of 2) or (2 of 2) was added in case the unit tray was not large enough for the collected specimens (Appendix 2).

After all specimens were pinned and organized into the unit trays the unit trays were kept for 24 hours in my desk to allow some of the moisture associated with the specimens to dissipate before the unit trays were stacked in airtight Tupperware containers and stored in the dark until identification.

In the instance that too many specimens were collected to allow pinning within the same day of collection, the sealed traps were kept for no more than 24 hours in my indoor freezer to keep the specimens from drying out and becoming brittle. They were then removed, thawed for 10-15 minutes and prepared in the standard fashion.

Specimen Identification

Blow flies were identified using the unpublished illustrated key from Dr. Terry Whitworth based on his 2006 work that was presented at the Davis, California 2016 NAFEA (North American Forensic Entomology Association) annual meeting “Fly Identification Workshop”. After I became very familiar with the most plentiful and most easily identified species, a checklist of features to look for was typed up and kept handy

to speed up identification. If at any time a specimen was not immediately identifiable it was set aside and the full pictorial key was run through. All were identified using a Leica ZOOM 2000 stereo microscope.

Most specimens will be retained within the Royce Cumming private collection, and representatives of most species will be donated to the Los Angeles County Natural History Museum.

Review of trap design

RC Bait Trap: Bioquip Product #1420RC (Figure 7).

Pros

· Small size: Ideal for urban settings due to its small size/ can keep many packed up together for storage or transportation/ small size also helps keep the odor of the bait to a minimum for those around, but is still enough to attract large numbers of insects (in one testing instance 250+ blow flies were collected over a 7-hour period in South Carolina using these traps).

· Designed so the top and bottom can be removed from the middle (middle can be left hanging in place if desired to maintain the same location throughout a survey) and top/bottom put together to keep collected specimens easily contained.

· To date no species have proven to be overly "trap weary" of this design (Table 6).

This trap was significantly tested by Royce Cumming from 2016-2018 in South Carolina, Indiana, Illinois, Nebraska, Colorado, Utah, Arizona, and California with great success. It has also been tested in numerous environments, ranging from coastal saltmarsh at sea-level up to high desert at 4,300 feet elevation with strong winds, high elevation mountain

lakes at over 7,000 feet elevation, and numerous locations and environment types in-between.

· Economically priced, currently about $16.00 ea. available as a new BioQuip product.

Cons

· Do to small trap size only small portions of bait can be used at a time which limits the length that traps can be hung and active (unless bait is switched out every 4-5 days or water is added to rehydrate). The environment that the trap is hung in will determine how long the bait will remain active, with dry hot environments desiccating bait more rapidly than humid environments.

· Pungent bait can be an attractant to ants which in several test instances entered the trap, ate the collected live specimens and then left the trap empty. This annoyance can be remedied by placing a ½ inch piece of Vaportape 1196F in the top chamber to kill any ants that enter, or if desired to keep the trap toxin free to collect live specimens a coating of Tangle-Trap Brush On Sticky Trap Coating can be added to the two hanging lines to keep ants from reaching the trap.

· If a larger size is desired there is a model that can hold about 2X the amount of bait and flies but is obviously larger and therefore loses the perks of a small trap. But the larger size allows more bait and therefore a longer period of activity can be maintained.

Table 6. Species caught during testing of RC Bait Trap and thesis collections, from 2016 2018, using putrefied beef and chicken liver as bait. Beef to chicken liver ratio of 2 to 1.

Order	**Family**	**Genus/Species**	**Common Name**
Diptera	Calliphoridae	*Phormia regina*	Black Blow Fly
		Calliphora latifrons	Blue Bottle Fly
		Calliphora vomitoria	Blue Bottle Fly
		Calliphora vicina	Blue Bottle Fly
		Calliphora terraenovae	Blue Bottle Fly
		Calliphora coloradensis	Blue Bottle Fly
		Calliphora montana	Blue Bottle Fly
		Chrysomya megacephala	Oriental Latrine fly
		Chrysomya rufifacies	Old World Screwworm
		Lucilia sericata	Green Bottle Fly
		Lucilia mexicana	Green Bottle Fly
		Lucilia illustris	Green Bottle Fly
		Lucilia coeruleiviridis	Green Bottle Fly
		Lucilia cuprina	Australian Sheep Fly
		Cochliomyia macellaria	Secondary Screwworm
		Compsomyiops callipes	False Screwworm Fly
		Protophormia terraenovae	Northern Blow Fly
		Cynomya cadaverina	Shiny Blue Bottle Fly
		Pollenia sp.	Cluster Flies
	Sarcophagidae	7+ species	Flesh Flies
	Muscidae	8+ species	House/Stable Flies
	Psychodidae	*Psychoda sp.*	*Drain Flies*
	Sepsidae	7+ species	Black Scavenger Flies
	Fungus Gnats	Several families	Fungus Gnats
	Many assorted micro-dipteran	25+ species, multiple families	Micro-Flies
Coleoptera	Silphidae	*Nicrophorus* sp.	Burying Beetles
	Staphylinidae	7+ species	Rove Beetles
	Histeridae	4+ species	Clown Beetles
	Dermestidae	2 species	Carpet/Museum Beetles
Hymenoptera	Chalcididae	*Brachymeria* sp.	Chalcidid Wasp
	Vespinae	*Vespula* sp.	Yellow Jackets
	Formicidae	3+ species	Ants
	Apidae	*Apis mellifera*	Honey Bee
Lepidoptera	Noctuidae	3+ species	Noctuid Moths
	Micro-moths	6+ species	Micr-moths
Neuroptera	Chrysopidae	*Chrysoperla* sp.	Green Lacewing
Araneae	Salticidae	2+ species (likely simply attracted as a hiding place, not attracted due to bait)	Jumping Spiders

Survey of previous collections

To supplement the active trapping survey, I also reviewed various additional collections to help fill in the missing months of collection. These collections included he Los Angeles Natural History Museum (18 drawers), my own private collection with specimens collected outside of the normal survey traps or times, and the private collection of forensic entomologist David Faulkner. Literature records from James (1955) were also reviewed and included in the specimen records and records from James (1955) which were clearly marked as those historic specimens within the Natural History Museum of Los Angeles collection were only listed once.

RESULTS

In total 4,933 blow fly specimens were collected during the active trapping survey, representing four subfamilies, seven genera, and thirteen species. Two species represented a vast majority (87.9%) of the specimens collected during this survey; *Chrysomya rufifacies* (3,022 specimens, 61.3%) and *Lucilia sericata* (1,313 specimens, 26.6%). The total number of blow flies collected in trap locations during the time period surveyed ranged wildly from a total of 7 (trap location: P, Mojave Desert) to 581 specimens (trap locations: C, urban; K, Santa Monica Mountains).

Table 7. Species checklist for forensically significant blow flies recorded by James, 1955 from Los Angeles and surrounding counties, as well as those species recorded from this study and the quantity of each species collected during the thesis time period.

		From James, 1955				
Species	Current Survey	Los Angeles	Ventura	Kern	San Bernardino	Orange
Lucilia cuprina	44	X				
Lucilia mexicana	36	X				X
Lucilia sericata	1,313	X			X	X
Calliphora grahami		X		X	X	
Calliphora coloradensis	8	X			X	X
Calliphora livida	3	X			X	
Calliphora terraenovae		X			X	
Calliphora vicina		X				
Calliphora vomitoria	2	X			X	
Calliphora latifrons	141	X		X	X	
Cochliomyia macellaria	112	X	X	X	X	
Compsomyiops callipes	13	X	X		X	
Phormia regina	37	X	X	X	X	X
Protophormia terraenovae					X	
*Chrysomya rufifacies**	3,022					
*Chrysomya megacephala**	181					
Pollenia sp.	15					
Unidentified Calliphoridae	6					
Total collected during thesis survey	**4,933**					

*Neither species were present at the time of James 1955 work on the blow flies with both species entering in the 1980's *Chrysomya megacephala* (Greenberg, 1988), and *Chrysomya rufifacies* (Baumgartner, D. L.,1986).

SUBFAMILY Polleniinae

***Pollenia* sp.** Robineau-Desvoidy, 1830

Thesis locations collected: B, D, K, V.

None reviewed while in Los Angeles Natural History Museum collection.

Discussion: This genus represents the “Cluster Flies/ Attic Flies/ or Buckwheat Flies” a group with no forensic significance due to their host preference for earthworms in the genera *Allolobophora* Eisen, 1873, *Eisenia* Michaelsen, 1900 and *Lumbricus* Linnaeus, 1758 (Heath, 2008).

With their lack of forensic importance, I simply confirmed the specimens caught to the genus level (identifiable from other Calliphoridae genera by the dense golden setae throughout the surface of the thorax: Whitworth, 2006) and noted their collection sites (Fig. 8).

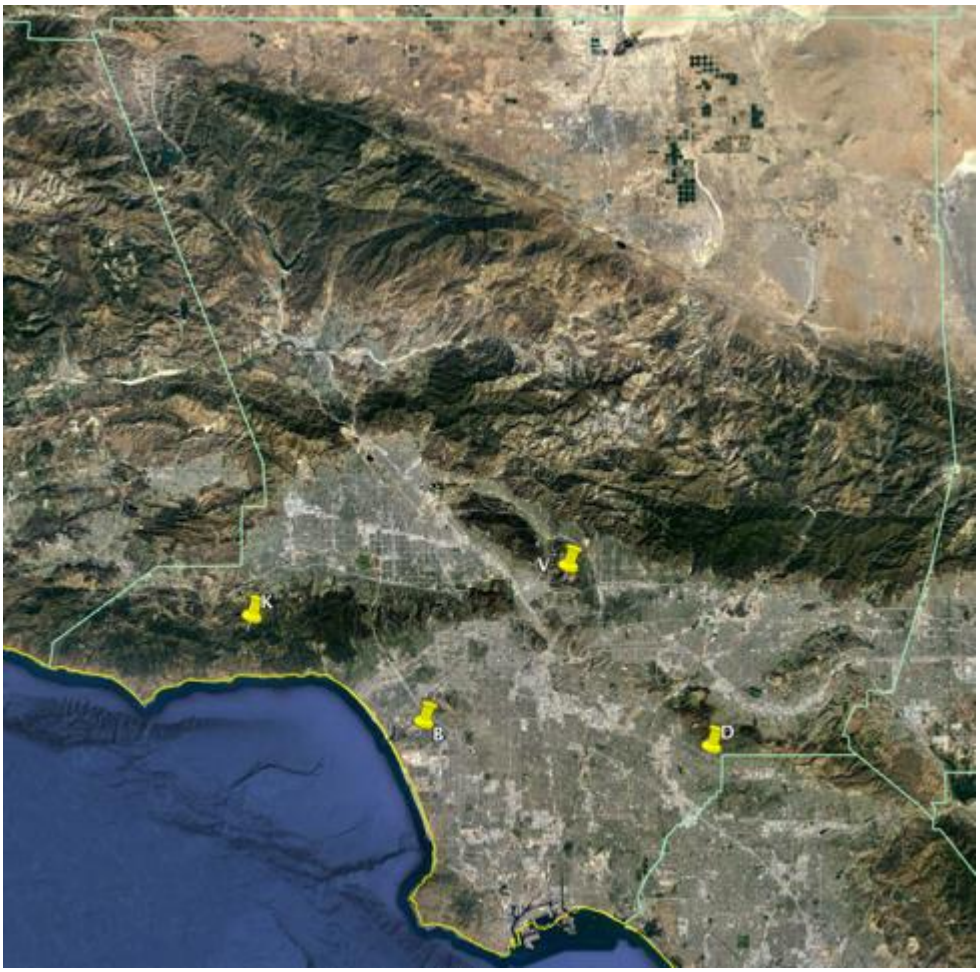

Figure 8. Active survey collection sites of *Pollenia* sp. in Los Angeles County, California.

SUBFAMILY Calliphorinae

Calliphora grahami Aldrich, 1930

Thesis locations collected: NONE.

Historic Collection Records: Echo Lake, 8/1932; Westwood Hills, LA Co. California, 4/2/39; Van Nuys, LA County, V/14/1936; Crystal Lake, VI-29-50 (J.C.Hall, UCD) (James, 1955); Crystal Lake, VII-9-52 (J.K. Hester, UCD) (James, 1955); Crystal Lake Road, 4'700', VII-9-52 (W.V.Garner, CIS) (James, 1955); Mt. Wilson, Opids Camp, V-14-37 (J. Wilcox, P.A.) (James, 1955); Sierra Madre, V-17-41 (J. Wilcox, P.A.) (James, 1955); Camp Baldy, VI-26-50 (J.D. Paschke, CIS) (James, 1955).

Discussion: One of several invasive species of blow fly reported in Los Angeles County, this species was originally from Asia (Whitworth, 2006) and first recorded in the United States in 1929 (Nunez-Vasquez, et al., 2010).

This uncommon species for Los Angeles County had no recent collection records, no more recent than 1932 through 1952 (James, 1955) with no additional specimens located within private collections or collected during this active survey. It appears as though this invasive species did not get a substantial foothold within Los Angeles County and even while it was present it was only recorded from April through August, never during the cooler times of the year. It did however have a significant range of elevations over which it was found, with historic records from 400 to 5,500 feet elevation with records from both the Urban and San Gabriel Mountain ecoregions (Fig. 9).

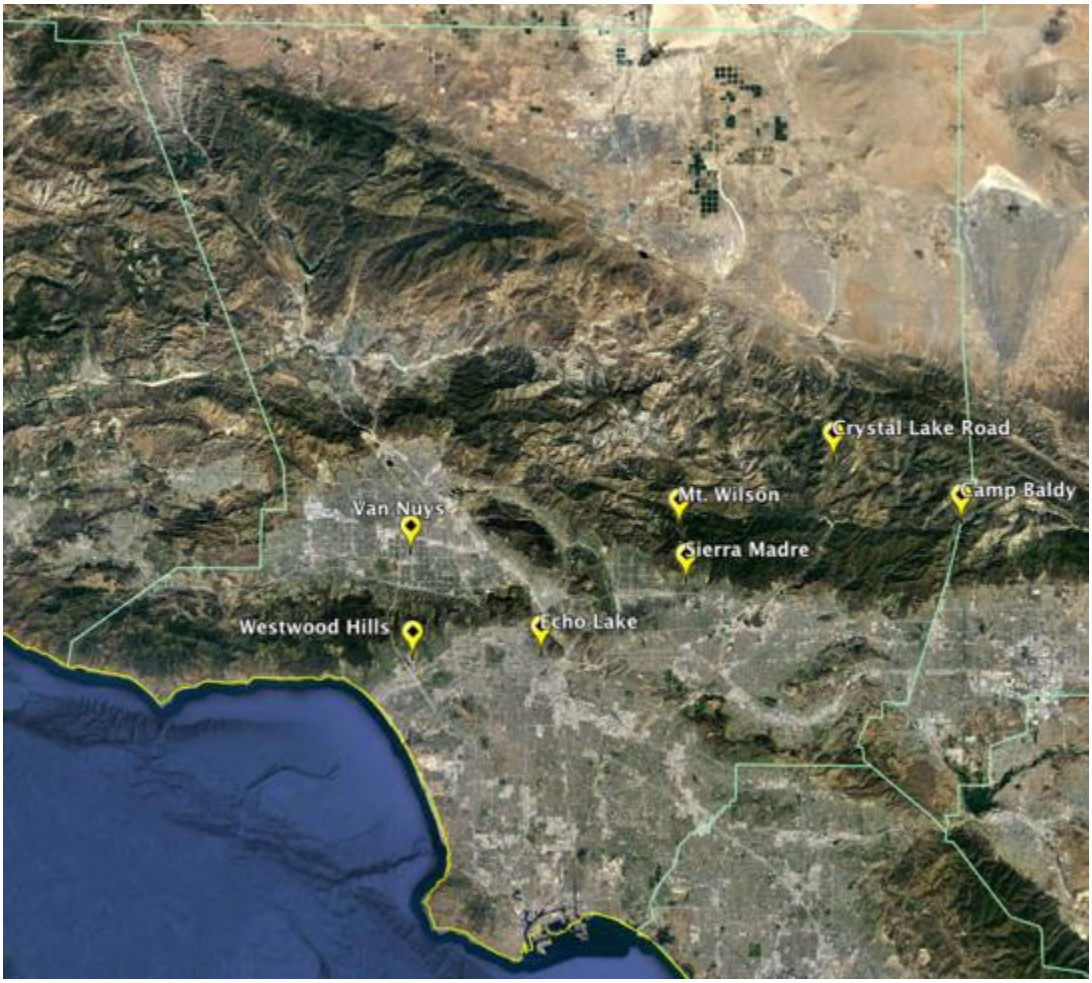

Figure 9. Historic and active survey collection sites of *Calliphora grahami* Aldrich, 1930 in Los Angeles County, California.

Calliphora coloradensis Hough, 1899

Thesis locations collected: J, M, O, S, Z.

Historic Collection Records: Little Rock Dam, LA Co. May 12th, 1979; Ranch 2.5 mi. S.S. W. of Valyermo LA Co., 4,800ft, VI-14-1959; Crystal Lake, VII-9-52 (J. K. Hester, UCD) (James, 1955).

Discussion: This species has been reported as uncommon by Whitworth (2006) but with a reasonably wide range reported by Hall (1948) with the species found from Mexico to Alaska, and east to Indiana and Ontario. With only 8 specimens found out of the 4,933

(0.1%) I agree with Whitworth (2006) as to the uncommon nature of this species. It is also worth noting that even though this species has a wide range of elevations where it can be found, 600 to 6,930 feet elevation, no records exist for the highly urbanized Los Angeles Basin, with it only known from The Santa Monica Mountains, San Gabriel Mountains, and the Mojave Desert (Fig. 10). *Calliphora coloradensis* has records from January, May through July, and from October, which suggests it could be a species found throughout the year, but due to its incredible rarity, may simply lack full temporal collection records.

Figure 10. Historic and active survey collection sites of *Calliphora coloradensis* Hough, 1899 in Los Angeles County, California.

Calliphora latifrons Hough, 1899

Thesis locations collected: B, C, D, F, G, I, J, K, L, M, N, O, P, R, S, T, U, V, W, Y, Z.

Historic Collection Records: Santa Monica, IV-13-1950; Westwood Hills, LA County CA I-1952; Westwood Hills LA Co. II-10-53; Westwood Hills LA Co. Apr.1939; Westwood Hills LA Co. 3-39; Westwood Hills I-52; Venice, LA County CA, 5-23-1953; Pacific Pal. LA Co. XII-2-51; Pacific Pal. LA Co. IX-23-51; Pacific Pal LA co. XI-17-51; Bev. Glen Canon StaMonica Mts. LA Co. II-22-52; Bev. Glen LA Co. VI-5-52; Beverly Glen Sta Monica Mts V-21-52; Beverly Glen Canyon Santa Monica Mts. LA Co. I-10-65; Eagle Rock LA Co. Nov. 7th 1954; Ang. Crest HWY San Gabriel Mts. LA Co. III-27-1955; Castiac LA Co. V-6-1950; Sta.Monica Mts 4-12-57; Sta Monica Mts. III-14-53; Natural His.Mus. LA Co. 34.01N 118.28W 12.XI.1994; Botanical Gardens UCLA June 10-1979; Malibu Lake LA Co. 16-Nov. 1953; Sepulveda Canyon 14-June1970; Elysian Park La Co. 34.08N 118.24W 19.XI,1994; Descanso Gard LA Co. 1982; Westchester LA Co. 2-.IV.57; Sullivan Canyon W.L.A 21-June 1969; 9km N. of La Canada 34.25N 118.18W 17.XII,1994; Mt. Waterman, San Gabriel Mts. LA Co. elv. 7,000 ft 3.oct.1971; Old Ridge Route LA Co. Elv. 3,300 ft April, 1965; Los Angeles, LA Co., III-1941; Pasadena CA 3-21-1957; Pasadena LA C. 5-5-57; Upper Winter Creek LA Co. 34.21N 118.04 W 1July 1999; LA Mus. XII.15.34; Hancock Bldg LA 25.VI-58; Big Tujunga Cn. 19-VII-52; Pomona, CA 27-Jan. 1962; BelAir Area LA Co. VII-7.66; Ballona Wetlands nr Playa Del rey 24May 1981; San Fernando, LA Co. IV-5-53; Agoura LA Co. V-26-54; Agoura LA IV.7.54; UCLA Westwood III-7-55; 5 mi. s. Hidden Springs San Gabriel Mts. IV-3-55; Malibu Lagoon 16-Nov.1953; Madrona Marsh

Torrance 3-Apr,1976; Harmony Pines Camp, Wrightwood 34 38’9N 117 71 15W 1862 VI-2017; Blue Ridge Mt. Rod nr Inspiration Point 34.229N 117.4215W 2240m VI-2017; San Gabriel Mountains, Eagle Roost day use area, 34 21’ 15” N 117 52’ 40” W, 6,664 ft, Aug. 11th, 2017; San Gabriel Mountains, Past Café, 34 20’ 55” N 117 57’ 57” W, 6,275 ft, Nov. 12th, 2017; La Mirada, 26 Jan. 2015, N 33 53’ 00.36” W 118 01’ 23.74”, elv. 67 feet (D.K.Faulkner); La Mirada, 25 Feb 2013, N 33 53’ 00.36” W 118 01’ 23.74”, elv. 67 feet (D.K.Faulkner); Westwood Hills, I-1952, IV-1939, II-1953 (UCLA) (James, 1955); Los Angeles, IV-1936 (UCLA) (James, 1955); Beverly Glen, Santa Monica Mts, V-1952, VI-1952 , II-1952 (UCLA) (James, 1955); Santa Monica Mts. III-1953, V-1952 (UCLA) (James, 1955); Castaic, V-1950 (UCLA) (James, 1955); San Fernando IV-1953 (UCLA) (James, 1955); Palmdale, III-1941 (J.Wilcox, PA) (James, 1955); Lancaster, III-1947 (J.Wilcox) (James, 1955); Hermosa Beach, V-1938, XII-1937, (CIS) (James, 1955); Venice V-1953 (UCLA) (James, 1955); Pacific Palisades XII-1951, (UCLA) (James, 1955); Glendale VI-1952, XI-1950 (UCD) (James, 1955); Big Dalton Dam, VII-1952, VII-1950 (UCD) (James, 1955); Tanbark Flats, VII-1950, VII-1952 (UCD) (James, 1955); Crystal Lake VI-1950, VII-1952 (CIS) (James, 1955); Long Beach VI-1952, VI-1954 (WSC) (James, 1955).

Discussion: Easily the most common species of *Calliphora* within Los Angeles County, this species was collected at 21 of the 25 thesis locations, and also numbered fourth most common species over all with 141 individuals collected (~2.9%) right behind *Chrysomya megacephala* with 181 specimens (~3.7%). It was also found at all elevations throughout the county (sea level to 7,380 feet elevation, Fig. 11) and in all ecoregions (one of only five species found in all ecoregions). *Calliphora latifrons* was collected nearly all year,

except October. With it being such a common species temporally and geographically, the lack of specimens from October was surprising.

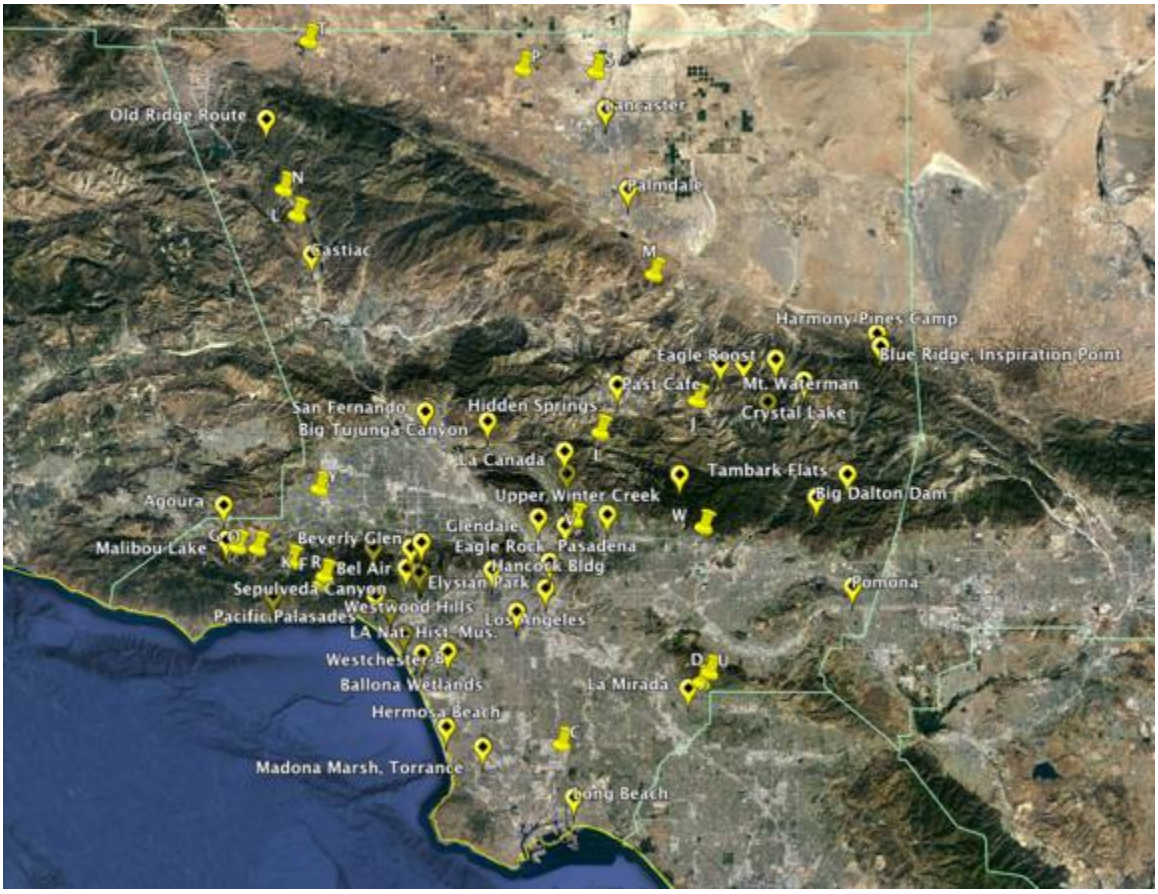

Figure 11. Historic and active survey collection sites of *Calliphora latifrons* Hough, 1899 in Los Angeles County, California.

Calliphora livida Hall, 1948

Thesis locations collected: M, Z.

Historic Collection Records: Crystal Lake II-9-52 (James, 1955); Camp Baldy VII-11-50 (James, 1955).

Discussion: This was an elusive species, only occurring at two trap locations with a total of three specimens collected (~0.06%) and with few records within the Los Angeles Natural History Museum. From previous collections, this species has been only found

during four months of the year: February, July, August, and October. With such a wide spread in temporal distribution and as a rarely recorded species, it is likely this species can be found throughout more months of the year but has just proven rare within the county. As one of the high elevation *Calliphora*, this species has only been found between 3,940 to 6,930 feet elevation within the San Gabriel Mountains (Fig. 12), and was one of only two species found exclusively about 3,000 feet elevation (the other being *Calliphora vomitoria*).

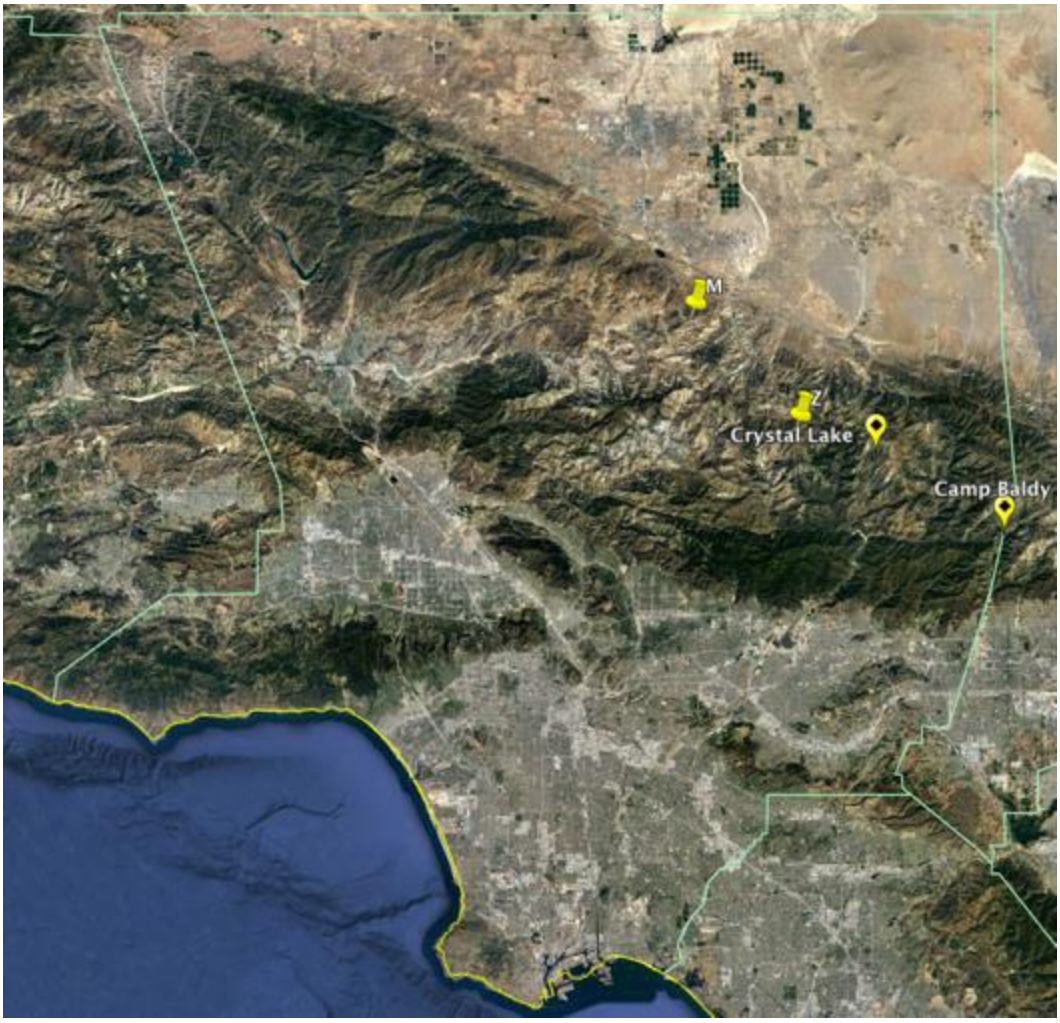

Figure 12. Historic and active survey collection sites of *Calliphora livida* Hall, 1948 in Los Angeles County, California.

Calliphora terraenovae Macquart, 1851

Thesis locations collected: NONE.

Historic Collection Records: Lancaster V-13-53; Crystal Lake VI-29-50; Crystal Lake VII-9-52 (D.E. Barons, UCD) (James, 1955).

Discussion: One of only three species exclusively collected above 2,000 feet elevation (the others being *Calliphora livida* and *Calliphora vomitoria*) and only known from the Mojave Desert and the San Gabriel Mountains at elevations from 2,390 to 5,800 feet (Fig. 13). This species is also very elusive or no longer present in Los Angeles County as no records more recent than 1953 were located and no specimens were collected during this survey. Whitworth (2006) recorded this species as widespread from Alaska to California and Wisconsin, Colorado, and New Mexico. Only historic records from May through July, no records from Winter or Fall.

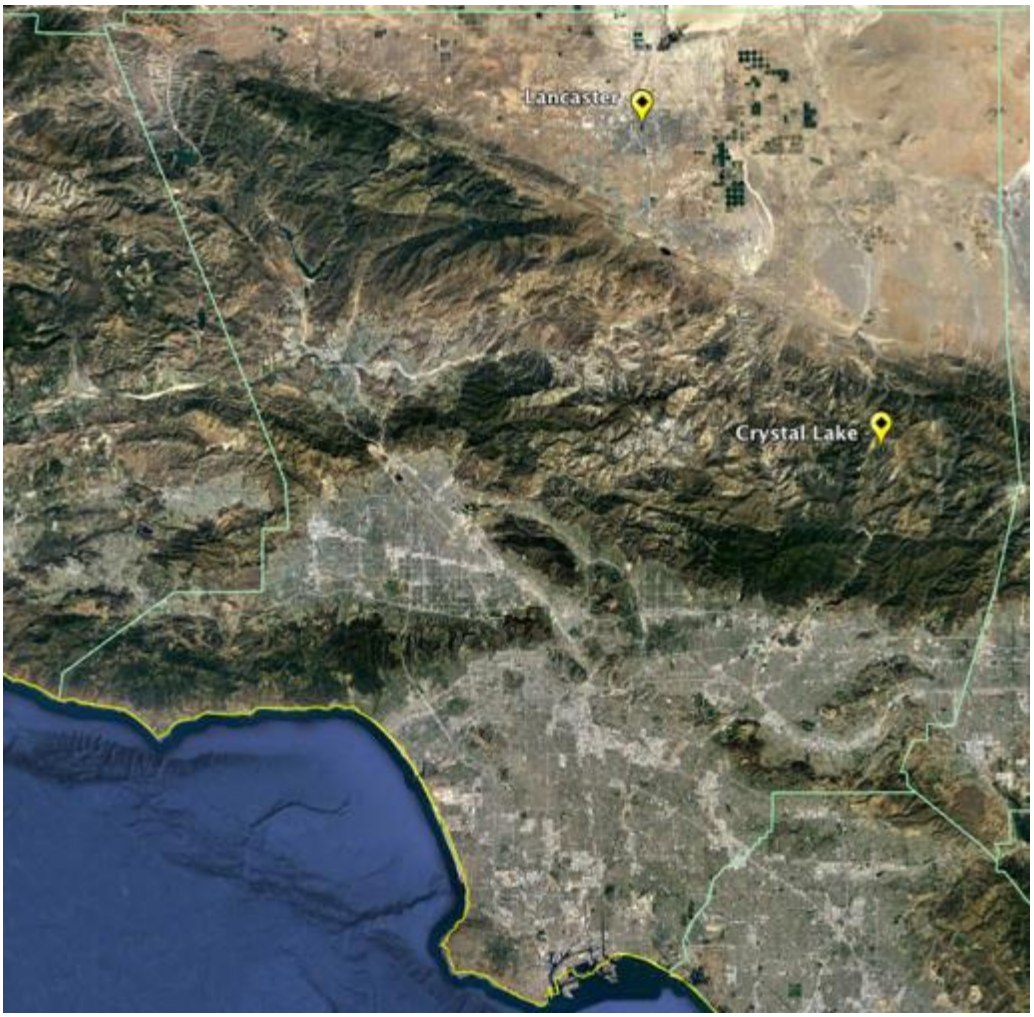

Figure 13. Historic and active survey collection sites of *Calliphora terraenovae* Macquart, 1851 in Los Angeles County, California.

Calliphora vicina Robineau-Desvoidy, 1830

Thesis locations collected: NONE.

Historic Collection Records: Redondo Beach 3/27/82; Alhambra 7-May 1982; West Los Angeles 5/30/1979; Los Angeles, LA Co. VII-16-1940; 9km N La Canada 34.25N 118.18W 17.XII.1994; Eagle Rock 4.IX.1988; Hancock Bld, 12.V.58; Ballona Wetlands near Playa del Rey 30 May 1980; S. Pasadena CA 5/11/80; Glendale, VII-18-48 (E.I. Schlinger, UCD) (James, 1955); Hermosa Beach, V-1938 (K.D. Snyder, CIS) (James, 1955); Tanbark Flat, VI-21-50 (H.M.Graham, CIS) (James, 1955).

Discussion: Reported as being widespread and common by Whitworth (2006), this species has proven to be anything but for Los Angeles County. It was one of three species which I did not collect during my thesis survey (the others being *Calliphora terraenovae* and *Calliphora grahami*), but unlike the other two species, this species has been more recently collected, with records from as recent as the 1980's. Looking at the temporal distribution it is likely that this species can be found throughout the year as records exist for March, May through July, September, and December. This was one of the lower elevation *Calliphora* species as it was found at a low range of elevations from sea-level up to 2,600 feet. It was also only found within the Urban ecoregion and in the foothills of the San Gabriel Mountains (Fig. 14).

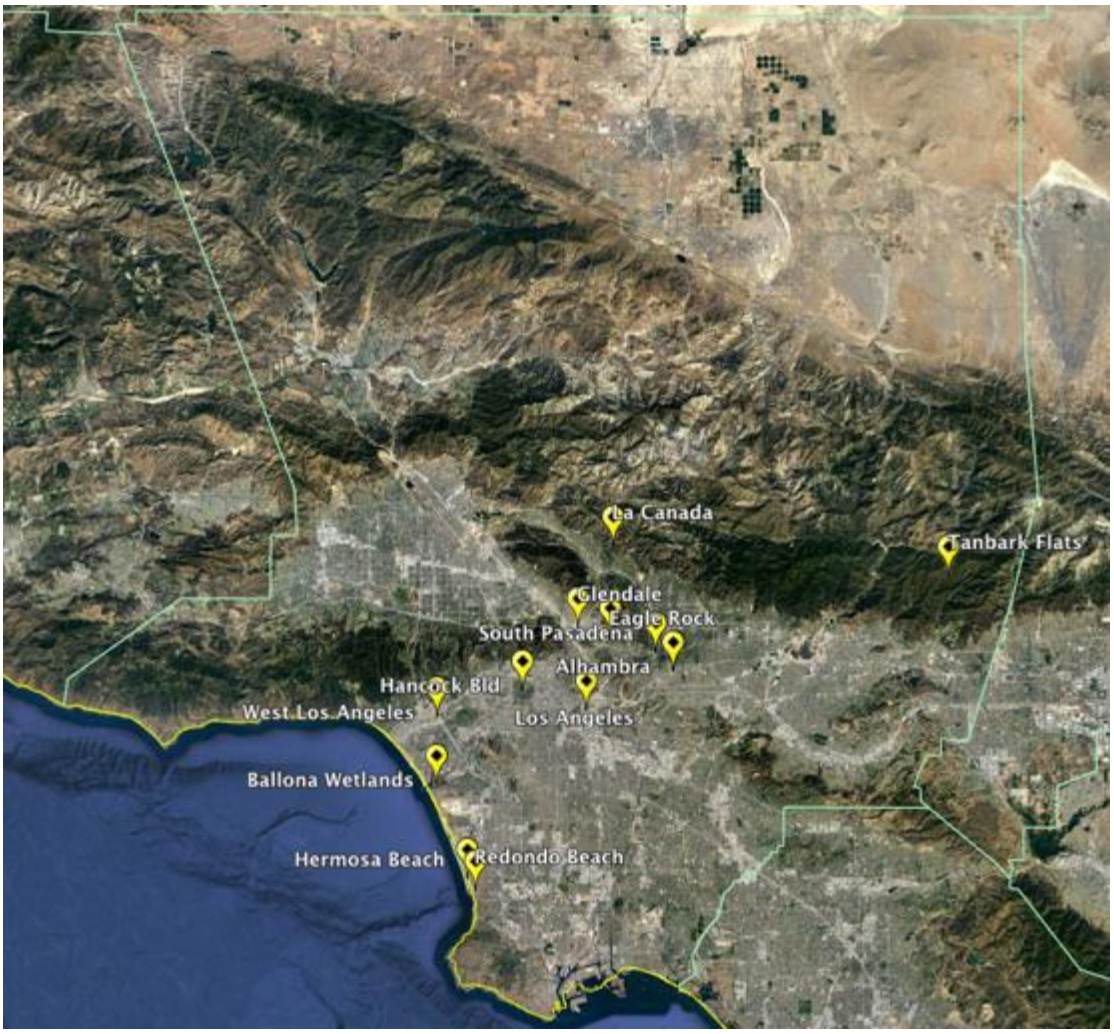

Figure 14. Historic and active survey collection sites of *Calliphora vicina* Robineau-Desvoidy, 1830 in Los Angeles County, California.

Calliphora vomitoria (Linnaeus, 1758)

Thesis locations collected: Z.

Historic Collection Records: Los Angeles Wrightwood Harmony pines Camp 34.389N 117.715W VI-2017 1862m.; Camp Baldy, VI-26-50 (K.G.Whitesell, UCD) (James, 1955); Crystal Lake, VI-29-50 (J.D.Paschke, CIS) (James, 1955).

Discussion: Of the species I collected during my survey, this was the rarest species with only a single male/female pair collected at my highest elevation trap in October, 2017

(Fig. 15). Historically for Los Angeles County, this species has only ever been found within the San Gabriel Mountains and was one of two species only known from this ecoregion (the other being *Calliphora livida*). Temporally this species has only been found during June and October in Los Angeles County. In other regions of the United States this can be a rather common species as reported by Whitworth (2006) but is without question an uncommon species for Los Angeles County. This species is one of the highest elevation species restricted to 4,300 feet to 6,930 feet elevation, which explains why it has not been found in another ecoregion within the county as both the Santa Monica Mountains and the Mojave Desert mostly fall short by at least 1,000 feet. This is also the only species within Los Angeles County found exclusively above 4,000 feet elevation.

Figure 15. Historic and active survey collection sites of *Calliphora vomitoria* (Linnaeus, 1758) in Los Angeles County, California.

SUBFAMILY Chrysomyinae

Chrysomya megacephala (Fabricius, 1794)

Thesis locations collected: A, B, C, D, E, F, Q, V, W, Y.

Historic Collection Records: Eagle Rock 16-Sep 90; La Mirada, 26 Jan. 2015, N 33 53' 00.36" W 118 01' 23.74", elv. 67 feet (D.K.Faulkner); La Mirada, 27 Jan. 2014, N 33 53' 00.36" W 118 01' 23.74", elv. 67 feet (D.K.Faulkner)..

Discussion: One of the two species which were absent during the time of James, 1955 (the other being *Chrysomya rufifacies*) this species is originally from the Oriental and Australian Regions and has since become widespread across many regions of the world

(Kurahashi, 1982; Badenhorst and Villet, 2018). This species was collected during every month of this survey and based on the common nature (third most common species collected) and ability to survive globally in many environments, it is likely if this survey was a full year long in scope, I would have expected this species to have been found year-round. This species was only found in the Urban and Santa Monica Mountain ecoregions (Fig. 16), unlike its congeneric *Chrysomya rufifacies* which was found in every thesis trap location. *Chrysomya megacephala* has a rather restricted range of elevations only found from near sea level to about 1,550 feet elevation and was one of only two species found below 2,000 feet elevation (the other being *Lucilia curprina* which was only found in the Urban ecoregion no higher than 1,000 feet elevation).

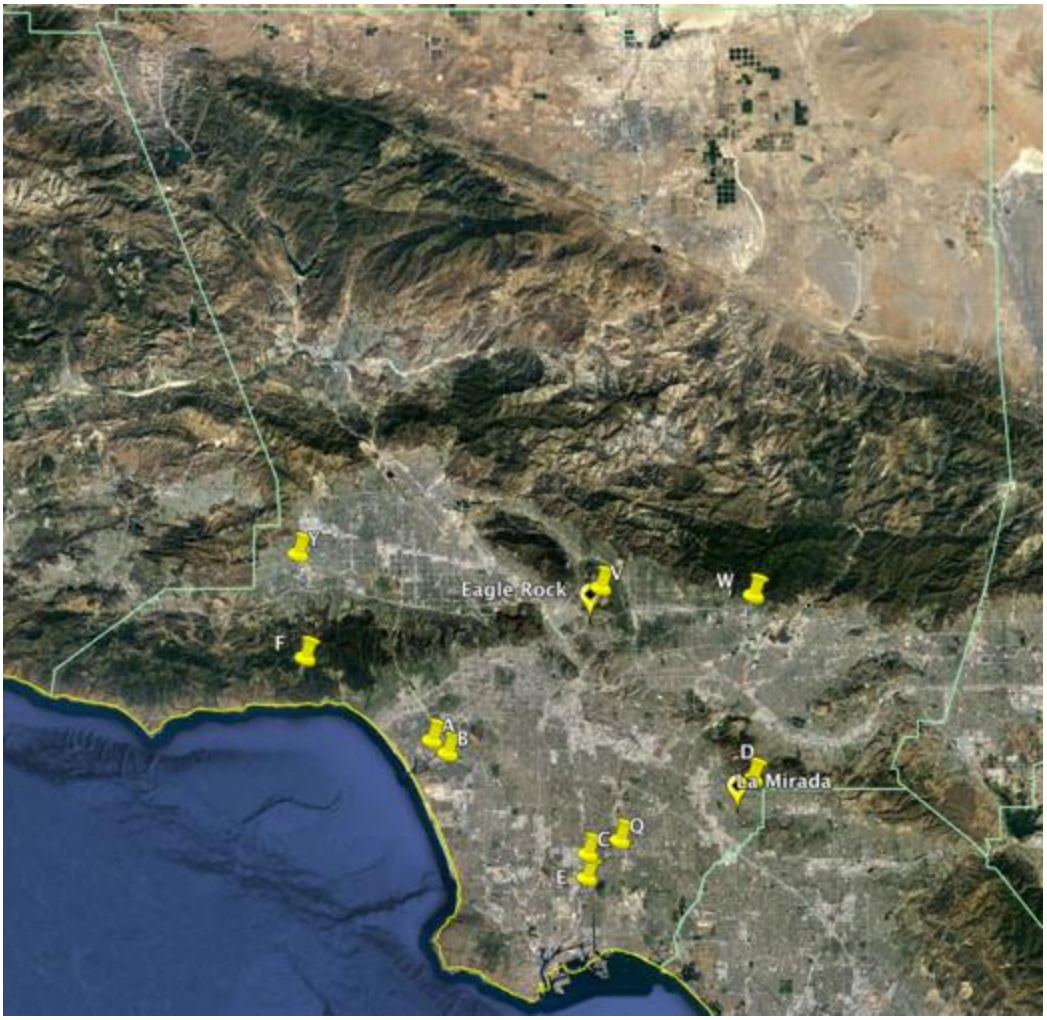

Figure 16. Historic and active survey collection sites of *Chrysomya megacephala* (Fabricius, 1794) in Los Angeles County, California.

Chrysomya rufifacies (Macquart, 1843)

Thesis locations collected: Collected at all twenty-five thesis locations.

Historic Collection Records: San Gabriel Mountains, near Vetter Mountain, Chalton Day Use area, 34 17’ 49” N 118 00’ 24” W, 5,353 ft, August 11th, 2017; Santa Monica Mountains, 34 06’ 07” N 118 42’ 51” W, 570 ft, Aug. 14th, 2017; La Mirada, 26 Jan. 2015, N 33 53’ 00.36” W 118 01’ 23.74”, elv. 67 feet (D.K.Faulkner); La Mirada, 15 June 2015, N 33 53’ 00.36” W 118 01’ 23.74”, elv. 67 feet (D.K.Faulkner).

Discussion: This invasive species was first recorded to the United States in the 1980s (Baumgartner, 1986) and since then has become the most common species in Los Angeles County. It can be found in all four ecoregions and during this survey was the only species found in all thesis trap locations. With 3,022 specimens collected (representing 61.3% of the total blow fly catch) this species was significantly the most common species collected, outnumbering all other species combined. This invasive species has proven to be very climate hardy with it withstanding environments from sea-level to high desert and 7,000 foot elevation cold mountain winters (Fig. 17). This species is likely collected within the county year-round, but because of the missing months of collection for this survey, only records for June through January exist at the present.

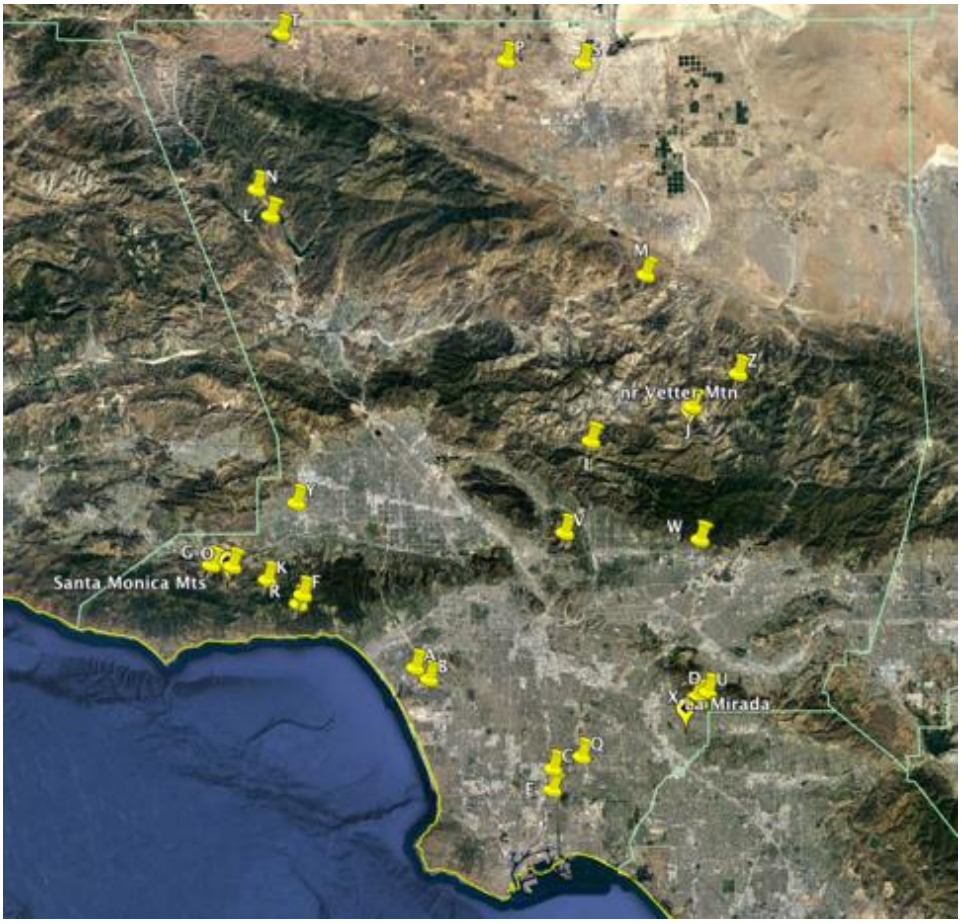

Figure 17. Historic and active survey collection sites of *Chrysomya rufifacies* (Macquart, 1843) in Los Angeles County, California.

Cochliomyia macellaria (Fabricius, 1775)

Thesis locations collected: B, C, G, K, L, M, N, O, Q, R, S, T, U, V, Y.

Historic Collection Records: Tanbark Flat LA Co. VII-17-1952; Big Tujunga Cyn VIII-20-52; Big Tujunga cn X-18-52(UCLA) (James, 1955); Los Angeles LA Co. VII-24 1941; Moody Springs LA Co. 4-Oct.1974; Tapia Park LA Co X-17-1970.

Discussion: This species was noted as common throughout North America by Whitworth (2006), and for this survey it was also common with it collected in all four ecoregions and represented 2.3% of collected blow flies (Fig. 18). Interestingly, despite it being common in Los Angeles County with historic records going back to the 1940's, this

species has only been recorded during the months of July through November with no records during the Spring. Despite being found in all four ecoregions, this species was only found from near sea level up to 3,940 feet elevation.

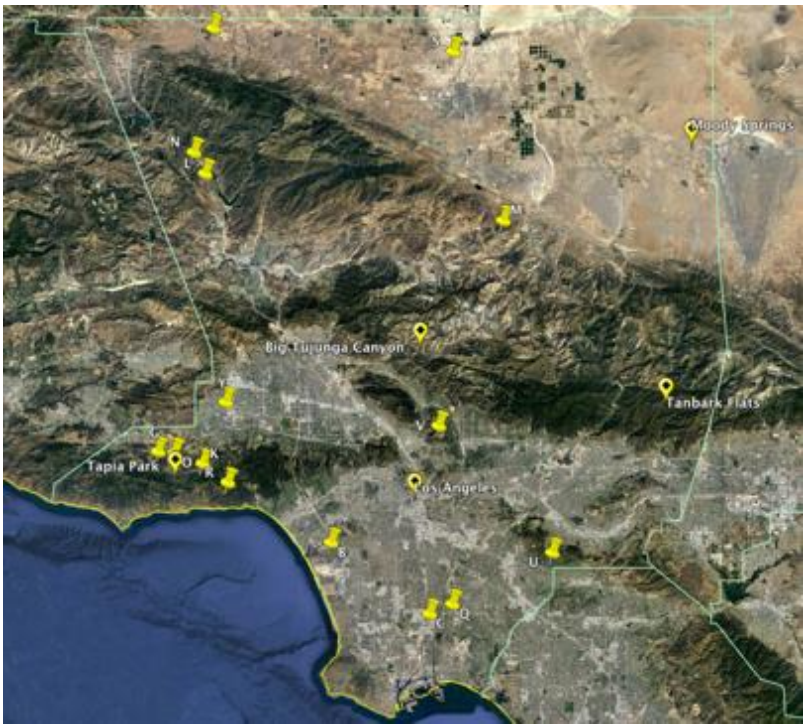

Figure 18. Historic and active survey collection sites of *Cochliomyia macellaria* (Fabricius, 1775) in Los Angeles County, California.

Compsomyiops callipes (Bigot, 1877)

Thesis locations collected: F, G, K, R, Z.

Historic Collection Records: Mi northeast of Canyon Entrance San Gabriel Canyon Oct 20 1945; StaMonica Mts. V-12-57; Santa Monica Mts V-51; StaMonica Mts. XII-29-53; StaMonica Mts. III-14-53; Big Tujunga Cn X-52; Brentwood II-53; Tanbark Flat VII-9-50; Tanbark Flat VII-17-1952; Crystal Lake VI-1950; Agoura V-26-54; L. Topanga Can LA co. V-26.65; Granada Hills 20 Apr 83; Westwood Hills 5-1935; Westwood Hills V-1940; La Canada 4/22/39; Angeles NF Blue Ridge rd. nr inspiration point, 34.229N 117.4215W 2240m June 2017; San Gabriel Mountains, Eagle Roost day use area, 34 21’

15” N 117 52’ 40” W, 6,664 ft, Aug. 11th, 2017; San Gabriel Mountains, Jarvi day use area, 34 21’ 20.67” N 117 51’ 36.95” W, 6,788 ft, Aug. 11th, 2017; Cape Canyon Catalina Island, VI-11-38 (T.D.A Cockerell CAS) (James, 1955); Tanbark Flat, VII-5-50 (W.A. McDonald UCLA) (James, 1955); Tanbark Flat, VI-23-50 (H.F.Robinson UCD) (James, 1955); Camp Baldy, VI-26-50 VI-26-50 (H.L. Hansen CIS) (James, 1955); Camp Baldy VII-7-52 (A.T. McClay UCD) (James, 1955); Big Dalton Dam, VII-12-50 (T.R.Haig, CIS) (James, 1955); Crystal Lake, VII-9-52 (S, Miyagawa, R.L.Anderson, UCD) (James, 1955); Crystal Lake VI-29-50 (D.C. Blodget UCLA) (James, 1955); Glendale, VI-8-52 (E.I.Schlinger, UCD) (James, 1955); Westwood Hills, V-5-38 (UCLA) (James, 1955); Big Tujunga Canyon X-12-51 (UCLA) (James, 1955); Santa Monica V-12-51 (James, 1955); Santa Monica II-14-53 (UCLA) (James, 1955); Stone Canyon, Santa Monica Mts. III-12-51 (UCLA) (James, 1955); Brentwood, II-16-53 (A.Fukushima, UCLA) (James, 1955); Sierra Madre, III-17-41 (J.Wilcox, P.A.) (James, 1955).

Discussion: *Compsomyiops callipes* was one of only four blow fly species recorded above 7,000 feet elevation (the others being *Calliphora latifrons*, *Lucilia sericata*, and *Phormia regina*). This species likely occurs in Los Angeles County throughout the year, but records were missing for January and September, as only 13 specimens were collected during this survey (representing 0.3% of totally blow flies collected). This species is most commonly found in the mountains, but there are records of it occurring in the urban environments at the foothills of the Santa Monica and San Gabriel Mountains, but never far from the mountains (Fig. 19). *Compsomyiops callipes* is one of several species not found in the Mojave Desert (the ecoregion with the fewest recorded species),

with *Lucilia mexicana* the only other species found in the urban and mountainous regions but not the desert.

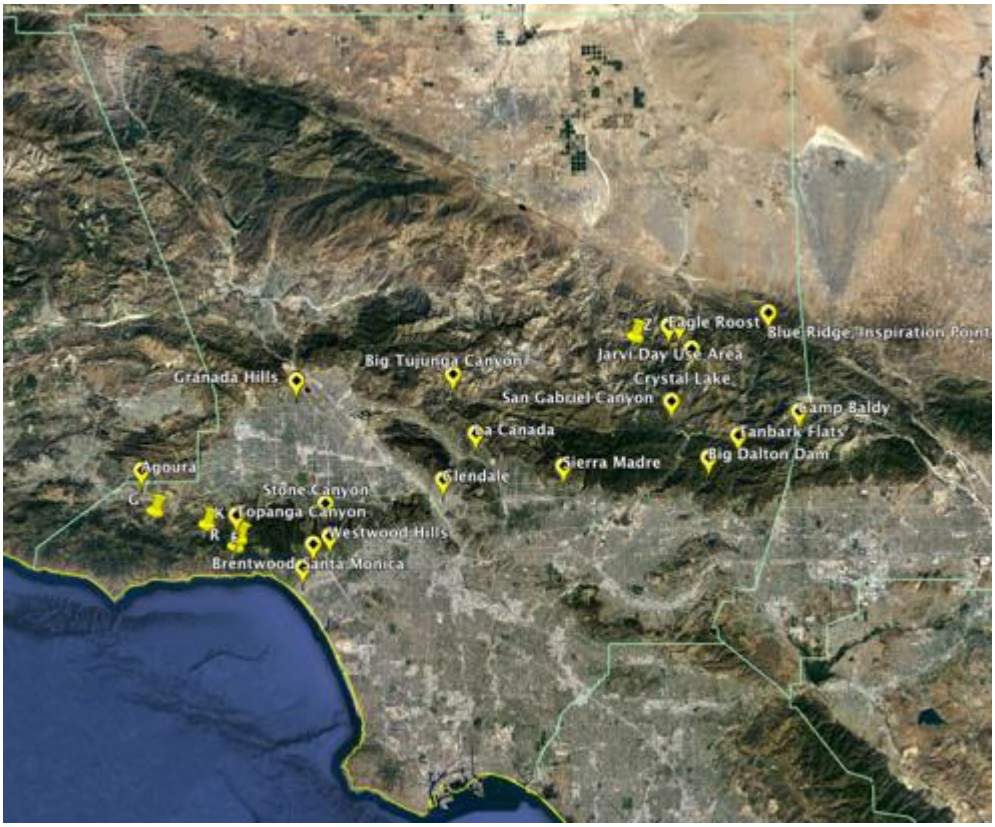

Figure 19. Historic and active survey collection sites of *Compsomyiops callipes* (Bigot, 1877) in Los Angeles County, California.

Phormia regina (Meigen, 1826)

Thesis locations collected: A, C, I, J, K, L, M, N, O, S, T, U, V, Z.

Historic Collection Records: Little Rock Dam May 12 1979; Palmdale 22.III.1970; Eagle Rock 23 Oct 1982; Monte Cristo P.C. 13 June 1969; Big Rock Creek May 13 1973; Tanbark Flat VII-1950; Tanbark Flat VII-1952; Crystal lake VI-1950; Camp Baldy VI-1950; Camp Baldy VII-50; Westwood hills I-52; Westwood Hills Mar.21.1953; Westwood Hills V-36; Pine Canyon VI-53; Crater Camp Mar. 1953; Oswald Trail Ang. Crest HWY San Gabriel Mts. III-55; Aberdeen Cyn Hollywood Hills Griffith Park VII-

1957; Angeles NF Mescal Creek Rd. 34 24’44”N 117 42’60”W 1580m VI-2017; Angeles NF Inspiration point 34 22’9”W 117 42’15”W 2240 m VI-2017; San Gabriel Mountains, Eagle Roost day use area, 34 21’ 15” N 117 52’ 40” W, 6,664 ft, Aug. 11th, 2017; San Gabriel Mountains, Jarvi day use area, 34 21’ 20.67” N 117 51’ 36.95” W, 6,788 ft, Aug. 11th, 2017; San Gabriel Mountains, Past Café, 34 20’ 55” N 117 57’ 57” W, 6,275 ft, Nov. 12th, 2017; Claremont, V-10-27 (CAS) (James, 1955); Westwood Hills, V-13-36 (J.Hopper, UCLA) (James, 1955); Westwood Hills, I-1952 (UCLA) (James, 1955); Tanbark Flats VI-20-50 (James, 1955); Tanbark Flats VII-3-50 (D.C.Blodset UCLA) (James, 1955); Tanbark Flats VIII-30-50 (E.B.Goodwin, UCD) (James, 1955); Elizabeth Lake Canyon III-28-53 (UCLA) (James, 1955); Crystal Lake VI-29-50 (W.A.McDonald UCLA) (James, 1955); Crystal Lake VII-9-52 (A.A.Grigarick UCD) (James, 1955); Camp Baldy VII-11-50 (James, 1955); Camp Baldy VI-26-50 (W.A.McDonald UCLA) (James, 1955); Big Dalton Dam, VII-13-50 (T.A.Haig, UCD) (James, 1955); Crater Camp III-21-53 (A.Ebeling, UCLA) (James, 1955); Crater Camp VII-12-50 (T. R.Haig CIS) (James, 1955); Pine Canyon VI-13-53 (W.A. McDonald, UCLA) (James, 1955); Middle Ranch, Santa Catalina Island III-26-38 (T.D.A. Cockerell CAS) (James, 1955); Pebbly Beach Santa Catalina Island IV-2-38 (T.D. A. Cockerell CAS) (James, 1955); Pomona, VII-20-31 (CIS) (James, 1955).

Discussion: *Phormia regina* is listed as common throughout North America by Whitworth (2006) and its abundance in all four ecoregions in Los Angeles County supports this. Although not overly abundant in numbers with only 37 specimens collected (0.8% of catch), this species can be found throughout each ecoregion as evident by its collection in 14 of the 25 thesis traps and with the abundance of historic records present

(Fig. 20). This species has records for most of the year with only the months of February and September lacking records. With such a wide range of months, it is likely that it could occur year-round and the rarity has simply allowed it to be over looked during these two months. *Phormia regina* was one of the most widely distributed species in elevation as well by occurring from near sea level up to 7,380 feet elevation.

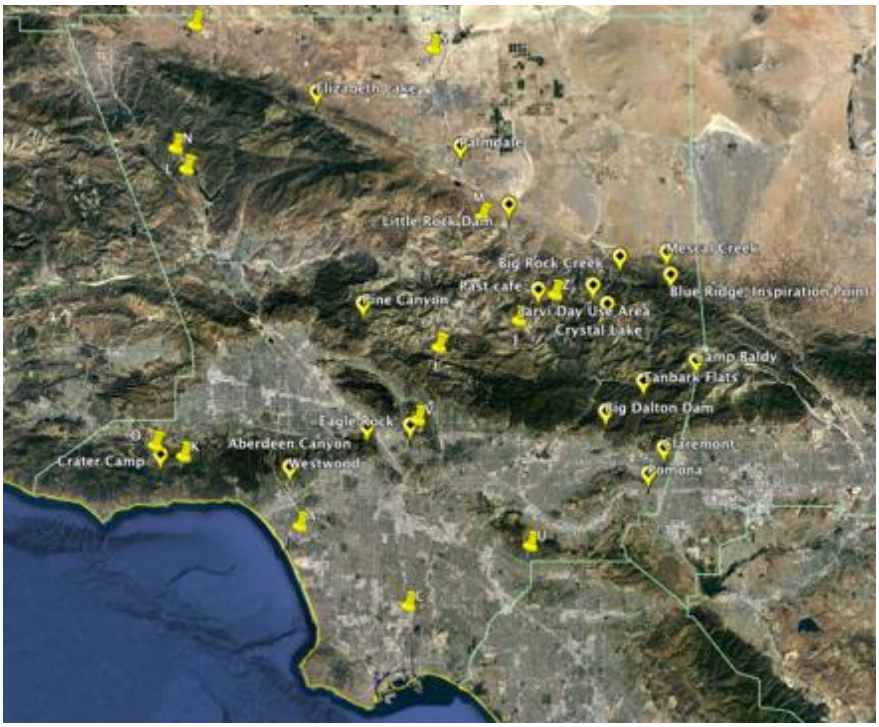

Figure 20. Historic and active survey collection sites of *Phormia regina* (Meigen, 1826) in Los Angeles County, California.

SUBFAMILY Luciliinae

Lucilia cuprina Weidemann, 1826

Thesis locations collected: B, C, D, E, Q, V, W, X.

Historic Collection Records: Elysian Park 34.08N 118.24W 19.XI.1994; Burbank Sept 25th 1950; Eagle Rock Oct 1982; Near USC Campus Oct 1963, Nat. Hist. Museu, 34.01N 118.28W XI-1994; Los Angeles, VI-2-49 (N.U.) (James, 1955).

Discussion: This species has only been found in urban disturbed environments below 1,000 feet elevation (Fig. 21). It was one of only three species which were found in a single ecoregion (the others being *Calliphora livida* and *Calliphora vomitoria* which were only found in the San Gabriel Mountains, both high elevation species so this is not surprising). Throughout this survey and historically for Los Angeles County this species was only collected from June through December (never found in late Winter or Spring) and was one of the less common species with only 44 individuals collected (0.8%) during this survey. Whitworth (2006) lists this species as a southern species uncommon throughout its range from Virginia, Missouri, and Florida to Texas and California.

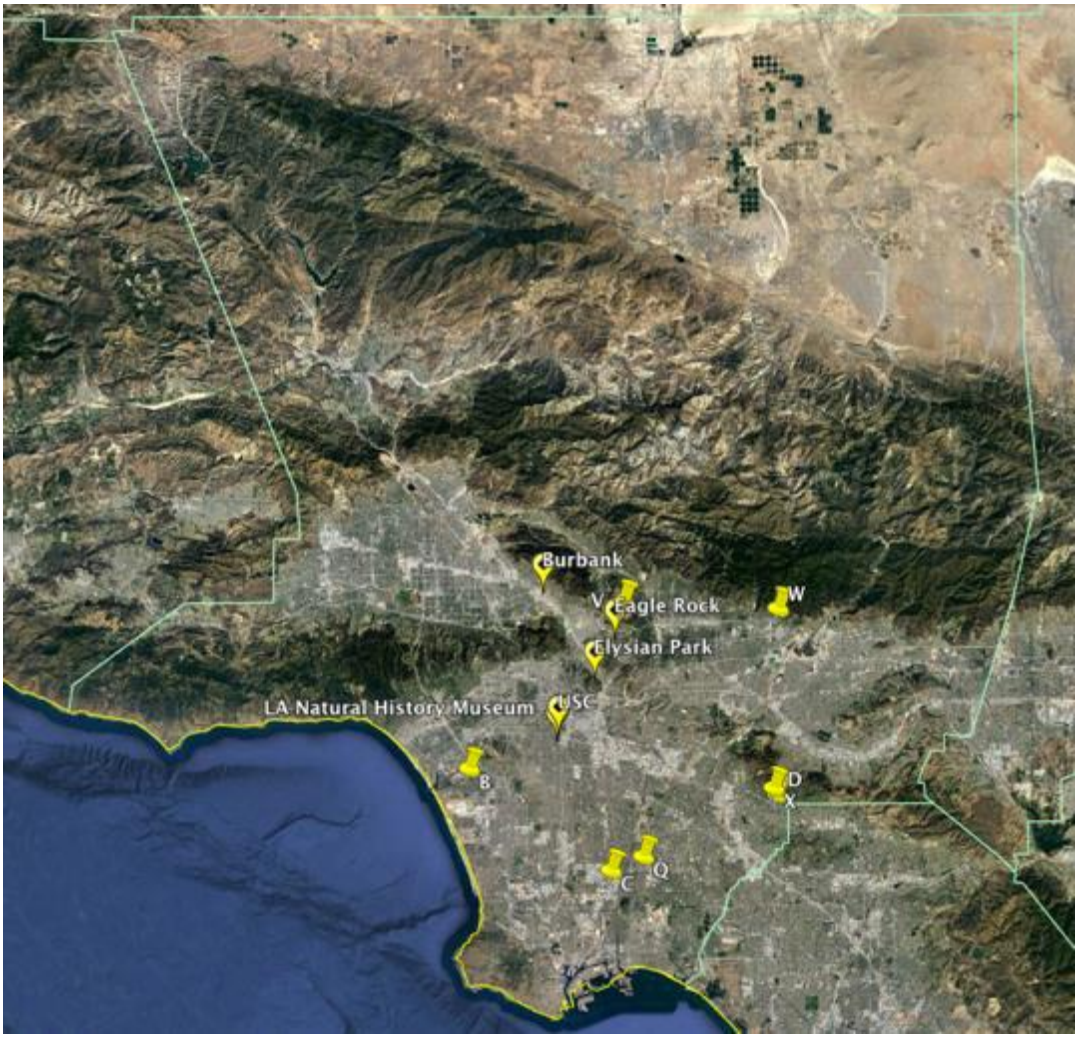

Figure 21. Historic and active survey collection sites of *Lucilia cuprina* Weidemann, 1826 in Los Angeles County, California.

Lucilia mexicana Macquart, 1843

Thesis locations collected: A, B, C, G, K, N, O, U, V, Y.

Historic Collection Records: Botanical Gardens UCLA June, 1979; Malibu Creek June-4 1972; Hollywood June, 1933; Nat. Hist. Mus. 34.01N 118.28W XI-1994; Descanso Gard. 24-Apr, 1982; Tapia Park 10 May 1978; Eagle Rock Oct. 1982; San Gabriel Mountains, Eagle Roost day use area, 34 21' 15" N 117 52' 40" W, 6,664 ft, Aug. 11th, 2017; Tanbark Flat, VI-21-50 (H.L. Hansen, C.I.S.) (James, 1955); Camp Baldy VII-11-50 (H.L. Hansen, C.I.S.) (James, 1955); Downey, V-1-34, to fresh Gopher (A.J. Basinger, C.A.S.) (James, 1955).

Discussion: *Lucilia mexicana* is found mid Spring through early Winter with only January through March lacking collection records. A rarer species representing only 36 (0.7%) specimens collected as compared to the congeners *Lucilia cuprina* (similar rarity with only 44 specimens collected) and strikingly less common than *Lucilia sericata* which was the second most common species during this survey with 1,313 specimens collected (26.6% of the collected blow flies). *Lucilia mexicana* is most common through the Urban and Santa Monica Mountain ecoregions, and was also found scattered in the San Gabriel Mountains and absent from the Mojave Desert (Fig. 22). Although about as common as *Lucilia cuprina* in numbers, *Lucilia mexicana* had a much wider range of elevations being found from about sea level up to 6,670 feet elevation in the San Gabriel Mountains.

Figure 22. Historic and active survey collection sites of *Lucilia mexicana* Macquart, 1843 in Los Angeles County, California.

Lucilia sericata (Meigen, 1826)

Thesis locations collected: A, B, C, D, E, F, G, I, J, K, L, M, N, P, Q, U, V, W, X, Y.

Historic Collection Records: Los Angeles LA Co. VII-1941; Los Angeles LA Co. 4-1957; Los Angeles LA Co. V-1941; Los Angeles LA Co. IX-1938; Eagle Rock IX-1988; Eagle Rock Oct. 1982; Eagle Rock V-1955; Burbank Sept, 1950; Hawthorne Backyard, 85’ elv, 11819 Van Ness Sep. 1971; Hawthorne Backyard, 85’ elv, 11819 Van Ness Oct 1971; Sta Monica Mts. 4-1957; Sta Monica Mts. V-1957; Sta Monica Mts. May 1972; Sta Monica Mts. V-1952; LA Zoo 29 Sept. 1941; Santa Monica April 1966; Santa Monica May 1972; Santa Monica IV-1950; Santa Monica V-1951; Alhambra Feb. 1966; Alhambra March 1966; Crenshaw Area Los Angeles V-1963; Crenshaw Area Los Angeles III-1963; Nat. Hist. Mus. 34.01N 118.28W XI-1994; Nat. Hist. Mus. July 1982; El Retiro Park VIII-1963; Madrona Marsh Torrance Oct.1975; Elysian Park 34.08N

118.24W XI-1994; Pasadena May 1965; La Canada June 1978; Pacific Pal. VI-1953; Pacific Pal. VI-1954; Malibu Lagoon Nov. 1953; Westchester III-1957; El Segundo Sand Dunes March 1939; Hancock Bld. V-1958; Hancock Bld. VI-1958; 10974 Wilshr XI-1967; 1423 W. 125th LA March 1974; Sullivan Cyn. July 1969; Sullivan Cyn. Jan. 1970; UCLA Campus X-1970; UCLA Campus V-1970; UCLA Campus XI-1970; UCLA Campus 4-1977; Redondo Beach March 1982; Little Rock Dam Road March 1973; Hidden Springs San Gabriel Mts. April 1961; West Los Angeles June 1973; Brentwood August 1969; Bel Air Area VII-1966; Tapia Park X-1970; Tapia Park XI-1970; Tapia Park III—1955; Tapia Park IV-1972; Tapia Mts. May 1962; Botanical Gardens UCLA June 1979; Botanical Gardens UCLA XII-1978; Botanical Gardens UCLA XII-1970; Westwood Hills May 1959; Westwood Hills May 1954; Westwood Hills March 1953; Westwood Hills VI-1935; Westwood Hills V-1940; Westwood Hills V-1950; Westwood Hills I-1952; LA Mus. XII-1939; Venice, May 1953; Tanbark Flat VII-1952; Pine Canyon VII-1954; San Fernando III-1953; San Fernando IV-1953; Ballona Wetland Near Playa del Rey June 1980; Ballona Wetland Near Playa del Rey March 1981; Ballona Wetland Near Playa del Rey July 1980; Sawtelle IV-1950; Westwood Village VII-1930; Van Nuys May 1936; Beverly Glen May 1949; Castaic May 1950; Chatsworth VII-1950; Malibu Lagoon Nov. 1953; Hollywood Jan. 1961; Encino III-1964; Encino IV-1964; Nat. Hist. Mus. 34.01N 118.28W XI-1994; Angeles NF, nr Inspiration Pt 34.229N 117.422W 2240 m VI-2017; Bob's Gap at HolComb Ridge Rd. 34.452N 117.813W 1224m VI.2017; Harmony Pines Youth Camp 1874 m. Jun, 2017 34.38848N 117.71500W; Jackson Lake Wrightwood 34 23'9"N 117 43'3"W 1850m VI-2017; La Mirada, 26 Jan. 2015, N 33 53' 00.36" W 118 01' 23.74", elv. 67 feet (D.K.Faulkner); Rancho Dominguez, BioQuip, 6

Oct. 2015, 33 51’ 10.41” N 118 13’ 17.21” W elv. 115 feet (D.K.Faulkner); Glendale, XI-25-50 (E.I.Schlinger U.C.D.) (James, 1955); Camp Baldy, VII-11-50 (H.S. Robinson, U.C.D) (James, 1955); Campus, UCLA, V-17-33 (UCLA) (James, 1955); Pomona VII-20-31 (James, 1955); Pomona X-9-31 (James, 1955); Hermosa Beach, X-30-40 (James, 1955); Hermosa Beach, V-1938 (K.D.Snyder, C.I.S.) (James, 1955); Los Angeles River, Long Beach, VI-26-54 (M.T.James W.S.C.) (James, 1955); Westwood Hills I-1952 (James, 1955); Westwood Hills IV-14-1952 (James, 1955); Westwood Hills VI-20-39 (James, 1955); Santa Monica, IV-13-50 (W.A. McDonald, UCLA) (James, 1955); Santa Monica, IV-26-50 (T.P. Kinsel, UCLA) (James, 1955); Castaic V-6-50 (W.A. McDonald, UCLA) (James, 1955); Sawtelle, IV-22-50 (UCLA) (James, 1955); Burbank IX-25-50 (E.H.Kardos, USAC) (James, 1955); Van Nuys V-12-36 (K.W. Opitz) (James, 1955); Beverly Glen, V-25-49 (G. Heid, UCLA) (James, 1955); Palms, VI-8-38 (D.L. Dow, UCD) (James, 1955); Soledad Canyon, IV-23-50 (W.A. McDonald, UCLA) (James, 1955); Big Tujunga Canyon, IV-11-53 (UCLA) (James, 1955); San Fernando, IV-13-53 (R.H.Orson, UCLA) (James, 1955); Carmelina, V-16-52 (H. Washburn, UCLA) (James, 1955); Venica, V-23-53 (G. Yamamoto UCLA) (James, 1955); Compton VI-20-52 (M.T.James W.S.C.) (James, 1955).

Discussion: *Lucilia sericata* is the second most abundant species in Los Angeles County representing 26.6% of the blow flies collected during this survey (1,313 specimens). This species showed a wide range of sizes and color forms with hues from blue and green to red. Common throughout the county, it was collected at 20 out of 25 thesis locations and found every month of the year. It was also one of the five species found in all four

ecoregions throughout Los Angeles County and occurred from Sea Level up to 7,380 feet elevation (Fig. 23).

Figure 23. Historic and active survey collection sites of *Lucilia sericata* (Meigen, 1826) in Los Angeles County, California.

DISCUSSION

With 4,933 blow fly specimens collected representing seven genera, and thirteen species, several trends became apparent in geographic and temporal distribution. Between each of the four ecoregions (Urban, Coastal Mountains, Interior Mountains, and High Desert), several species help to clarify these regions. *Lucilia cuprina* defines the urban disturbed environments as this was the only ecoregion the species could be found in, and was only recorded below 1,000 feet elevation. The San Gabriel Mountains (interior mountains) have two species which define this ecoregion; *Calliphora livida* and *Calliphora*

vomitoria (both only found from about 4,000 to 7,000 feet elevation). The San Gabriel Mountains also had the highest species diversity with 13 species recorded (only missing *Lucilia cuprina* which is only known from disturbed urban environments, and *Chrysomya megacephala* which is only known from the urban ecoregion and from the cooler Santa Monica Mountains). Of the seven *Calliphora* species found in Los Angeles County, all seven occur in the San Gabriel Mountains which is what helps to give this ecoregion its higher diversity (Table 8).

There are five species which occurred in all four ecoregions; *Phormia regina, Cochliomyia macellaria, Chrysomya rufifacies, Lucilia sericata, Calliphora latifrons* (Table 8). For the active survey specifically, despite several historic records, three species were not found at all, *Calliphora grahami* (not seen since 1952 (James, 1955)), *Calliphora terraenovae* (no records more recent than 1953 (James, 1955)), and *Calliphora vicina* (minimal records within the Los Angeles Natural History collection from 1938-1982, therefore much more recently collected than the other two but still not seen in several decades). These three species could simply be so rare that this short active survey did not collect them, or that any or all of these three species can no longer be found within Los Angeles County.

Table 8. Species diversity which classifies each ecoregion of Los Angeles County California based on historical records and the present survey.

Species/Region	Urban	Santa Monica Mts.	San Gabriel Mts.	Mojave Desert
P. regina	X	X	X	X
C. macellaria	X	X	X	X
C. callipes	X	X	X	
C. rufifacies	X	X	X	X
C.megacephala	X	X		
L. sericata	X	X	X	X
L. cuprina	X			
L. mexicana	X	X	X	
C. grahami	X		X	
C. coloradensis		X	X	X
C. livida			X	
C. terraenovae			X	X
C. vicina	X		X	
C. vomitoria			X	
C. latifrons	X	X	X	X
Species Richness	**11**	**9**	**13**	**7**

Despite three species not being found in the county which were present at the time of James (1955), two new species distribution records for species not present at the time of James are here added. Both *Chrysomya rufifacies* and *Chrysomya megacephala* have only been present in the United States since the 1980's (Baumgartner, 1986) and have not yet formally been recorded within the county until now.

Temporally, two species had rare records with only 2 months of collection ever recorded, *Calliphora terraenovae* (only May-June) and *Calliphora vomitoria* (only June and October). *Lucilia sericata* was the only species which had confirmed collections all year long, and several other species likely occur all year long but are missing a month or

two of confirmed records, *Phormia regina, Compsomyiops callipes, and Calliphora latifrons,* which could possibly have been due to the lack of a full year active survey or their rarity during those months of the year (Table 9). *Cochliomyia macellaria* has only been recorded from July through November (Summer and Fall only) and *Calliphora grahami* was only historically recorded from April through August (Spring and Summer only). *Chrysomya rufifacies* and *Chrysomya megacephala* were both regularly collected during this active survey but as invasive species there were no historic records to review, but with their commonality and regularity during this survey it is likely both species can be found in the county throughout the year which hopefully future collections will reveal. *Lucilia cuprina* was geographically isolated to the urban ecoregion and only had records for June through December (Summer, Fall, and early Winter, with no records from late Winter or Spring). *Lucilia mexicana* had a similar temporal span to *Lucilia cuprina*, except that *Lucilia mexicana* can be found two months earlier from April through December (mid Spring, Summer, Fall, and early Winter). Two species had rare occurrences without a discernable pattern *Calliphora livida* (July, August, October, February) and *Calliphora vicina* (March, May, June, July, September, December), likely these two species can be found all year long due to their natural rarity they have simply avoided regular collection.

Summer was the only season where all 15 species known for Los Angeles County have been collected, followed by Fall with 13 species, Winter with 11 species, and lastly Spring with only 9 species collected (although because my survey did not occur during the Spring I suspect that both invasive *Chrysomya* species likely occur as well which

would bring the total species for Spring equal to Winter with 11 species (summarized in Table 9).

Table 9. Temporal collection records of the species recorded from Los Angeles County as noted by month of collection. Includes both historic records from the Los Angeles County Museum as well as those collected during this thesis period.

Season	Spring			Summer			Fall			Winter		
Month	M	A	M	J	J	A	S	O	N	D	J	F
P. regina	■	■	■	■	■	■		■	■	■	■	
C.macellaria					■	■	■	■	■			
C. callipes	■	■	■	■	■	■		■	■	■		■
C. rufifacies				■	■	■	■	■	■	■	■	
C.megacephala					■	■	■	■	■	■	■	
L. sericata	■	■	■	■	■	■	■	■	■	■	■	■
L. cuprina				■	■	■	■	■	■	■		
L. mexicana		■	■	■	■	■	■	■	■	■		
C. grahami		■	■	■	■	■						
C.coloradensis			■	■	■			■			■	
C. livida					■	■		■				■
C. terraenovae			■	■								
C. vicina	■		■	■	■		■			■		
C. vomitoria				■				■				
C. latifrons	■	■	■	■	■		■	■	■	■	■	■
# of Species Present	5	6	9	11	13	10	8	12	9	9	6	4
Season (# of species)	Spring (9)			Summer (15)			Fall (13)			Winter (11)		

The distribution of species across elevations was rather interesting with three major trends appearing. First, are those species which were found at low elevations and below 4,000 feet elevation, these were: *Lucilia cuprina, Chrysomya megacephala, Calliphora vicina,* and *Cochliomyia macellaria* (exact elevations given in Table 10 and illustrated in Figure 24). Next were those species which did not occur down at sea level (could only begin to be found several hundred feet higher in elevation) and had a

maximum elevation of at least 5,000 feet elevation, these were: *Calliphora grahami, Calliphora terraenovae, Calliphora livida, Calliphora vomitoria,* and *Calliphora coloradensis*. Finally, were the species which were very widely distributed from sea level or nearly so, up to a minimum of at least 6,000 feet elevation with some found even past 7,000 feet. These widely distributed species were: *Lucilia mexicana, Chrysomya rufifacies, Lucilia sericata, Calliphora latifrons, Compsomyiops callipes,* and *Phormia regina*.

Table 10. Recorded lowest and highest elevations (in feet) for the forensically significant blow fly species in Los Angeles County.

Species	Lowest Elevation	Highest Elevation
Lucilia cuprina	30	1,000
Lucilia mexicana	20	6,670
Lucilia sericata	5	7,380
Calliphora grahami	400	5,500
Calliphora coloradensis	600	6,930
Calliphora livida	3,940	6,930
Calliphora terraenovae	2,390	5,800
Calliphora vicina	10	2,600
Calliphora vomitoria	4,300	6,930
Calliphora latifrons	0	7,380
Cochliomyia macellaria	50	3,940
Compsomyiops callipes	100	7,380
Phormia regina	20	7,380
Chrysomya rufifacies	20	6,930
Chrysomya megacephala	20	1,550

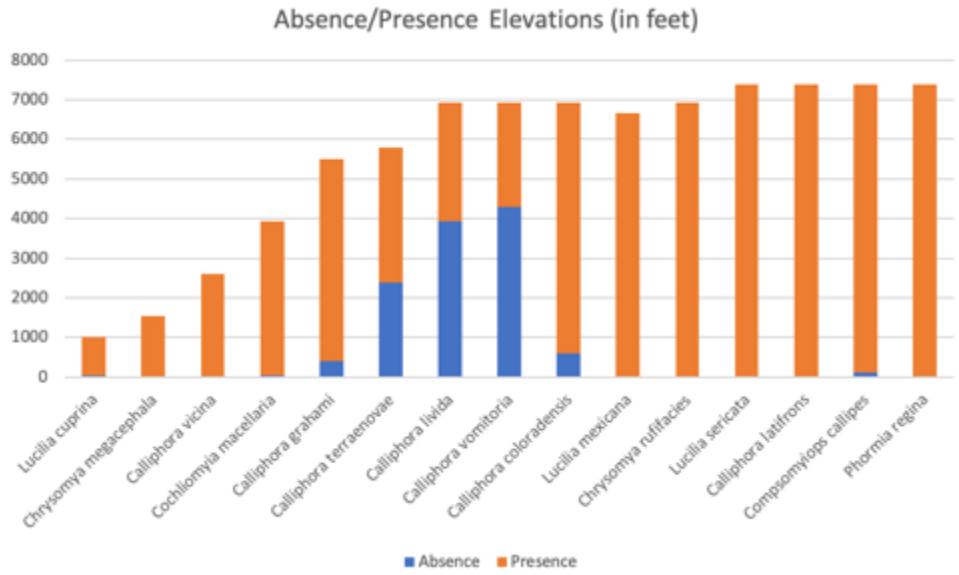

Figure 24. Elevations (in feet) where each species has been recorded. Figure includes the records from this active survey as well as all historic records.

Unfortunately, with this active survey not being conducted throughout a full calendar year it is difficult to extrapolate seasonality fully from the collected specimens. It is worth mentioning however that with Southern California's Mediterranean climate all year long, the likelihood that a species was missed because of a missing month of collection is unlikely.

LITERATURE CITED

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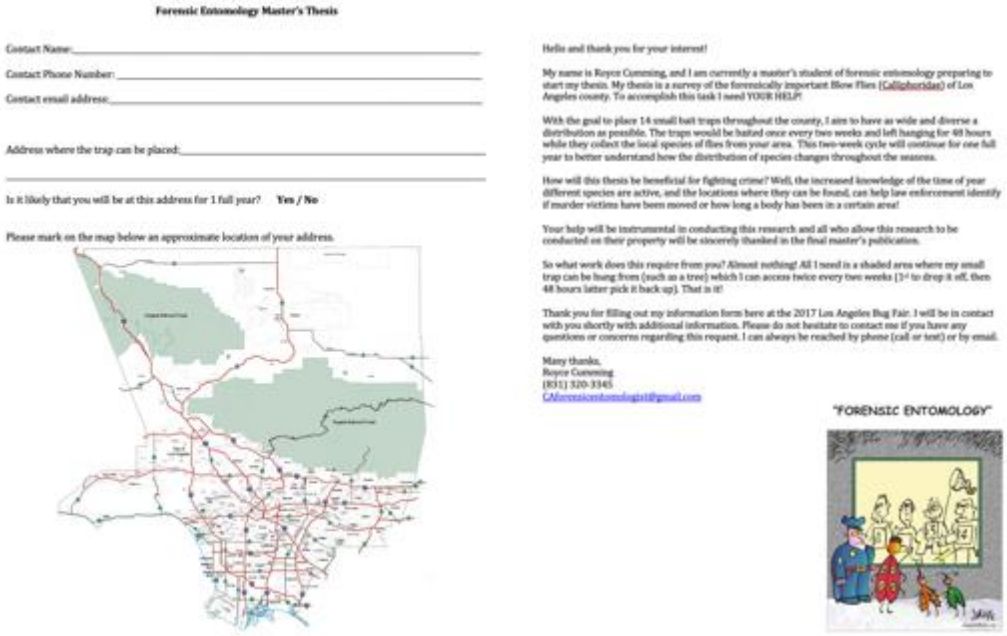
Appendices



Forensic Entomology Master's Thesis

Contact Name:_____

Contact Phone Number: _____

Contact email address:_____

Address where the trap can be placed:_____

_____

Is it likely that you will be at this address for 1 full year? **Yes / No**

Please mark on the map below an approximate location of your address.

Hello and thank you for your interest!

My name is Royce Cumming, and I am currently a master's student of forensic entomology preparing to start my thesis. My thesis is a survey of the forensically important Blow Flies (Calliphoridae) of Los Angeles county. To accomplish this task I need YOUR HELP!

With the goal to place 14 small bait traps throughout the county, I aim to have as wide and diverse a distribution as possible. The traps would be baited once every two weeks and left hanging for 48 hours while they collect the local species of flies from your area. This two-week cycle will continue for one full year to better understand how the distribution of species changes throughout the seasons.

How will this thesis be beneficial for fighting crime? Well, the increased knowledge of the time of year different species are active, and the locations where they can be found, can help law enforcement identify if murder victims have been moved or how long a body has been in a certain area!

Your help will be instrumental in conducting this research and all who allow this research to be conducted on their property will be sincerely thanked in the final master's publication.

So what work does this require from you? Almost nothing! All I need is a shaded area where my small trap can be hung from (such as a tree) which I can access twice every two weeks (1st to drop it off, then 48 hours latter pick it back up). That is it!

Thank you for filling out my information form here at the 2017 Los Angeles Bug Fair. I will be in contact with you shortly with additional information. Please do not hesitate to contact me if you have any questions or concerns regarding this request. I can always be reached by phone (call or text) or by email.

Many thanks,
Royce Cumming
(831) 320-3345
CAforensicentomologist@gmail.com

"FORENSIC ENTOMOLOGY"

Appendix 1. Informational sheet handed out at the 2017 LA Bug Fair to potential volunteers for trap locations.

Location #:_____
Date Collected:_____
Sampling ID #:_____
Location:_____
_____
_____
Contents:
_____
_____
_____
_____
_____
_____
_____
Unit Tray ___ of ___

Appendix 2. Sample of topper on unit trays for specimen organization.